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TREATISE ON PLANERS

PRACTICAL INFORMATION
AND
SUGGESTIONS FOR ECONOMICALLY PRODUCING FLAT SURFACES

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PREFACE

This volume has been prepared to aid those interested and confronted with the perplexing problems of one of the most interesting branches of machine building—the producing of flat surfaces quickly and accurately.

It is the idea of the following pages to help those called upon to select the proper machines for accomplishng the above result as well as aiding the experienced journeyman in the proper jigging up and use of the correct tools to produce the work at a minimum cost.

Special effort has been made to treat this subject in a clear and comprehensive manner, carefully avoiding all unnecessary matter and presenting to the apprentice and mechanic many points pertaining to the tools and fixtures with which they come in daily contact and about which they are often unable to obtain all necessary information in order that they may use these tools correctly and efficiently.

THE CINCINNATI PLANER CO.

February 1, 1912.

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A TREATISE ON PLANERS

THE EVOLUTION OF THE PLANER

In the early days of machine building, the only method known to produce a flat surface on metal was to use a hammer, cold chisel and file. The first was used on the roughing process and the file to finish. Then came the planer, the exact date is not clear but Fig. 1 shows what is believed to be the first planer built in this country. The bed is of granite and ways are of cast iron, which were chipped and filed. It was built in 1832 in the old Gay and Silver Shop in North Chelmsford, near Lowell, Mass. This planer is still in use and has marked the epoch in this very useful branch of mechanics.

If we pause here for a moment and reflect back to the first planer and then form a picture in our minds of a present-day high-speed planer we cannot but wonder at this marvelous development so that to-day the planer constitutes one of the most universal labor-saving machine tools in the equipment of any manufacturing establishment.

Electricity has also found its way into this development so that now a great many of our tools have individual motor drives. Electricity has also made possible the reversible motor drive on planers, thus dispensing with all belts and making a very flexible arrangement for varying both cut and return speeds at the will of the operator. High-speed steel tools and their proper shapes have also played an important part.

In the earlier days all roughing was done with one tool. To-day the planer is made to have two, three and four or even more tools for the roughing operation, at such speeds as 40 and 50 feet per minute.

To properly finish work on any machine in which the work is to be clamped securely while roughing, great care must be exercised in the right way of applying the clamps so as not to spring the work when released after finishing or to clamp a casting at its weakest point.

The contour of the finishing tool also requires some study to get the proper clearance in all directions, as too much clearance on a finishing tool frequently results in chatter as will be shown later.

For getting an absolutely smooth and true flat or round surface, nothing excels the single-point tool, for instance:

When we want to bore a really accurate hole, we use a single-pointed tool for the finishing cut. We often rough the hole out with a chucking reamer, or any other tool, but the single point puts on the finishing cut.

It is the same with finishing flat surfaces, if accuracy counts for anything.

The surface plate is the final test of all flat surfaces and in every instance, the surface plate is finished on a planer.

No lathe builder thinks of finishing his lathe beds by anything except plan-

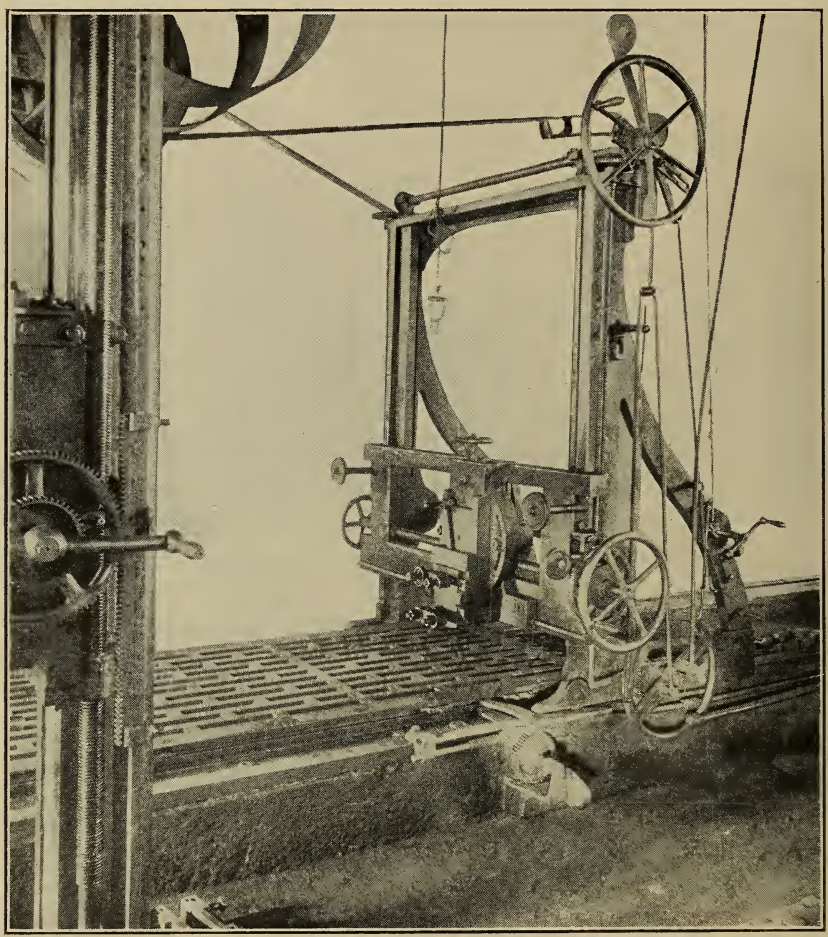


Fig. 1.—Old planer with stone bed.

ing. A few rough the stock off with the milling machine to relieve the skin tension and then let them season, but the finishing is always done on a planer, not from prejudice or habit but because they know that is the way to obtain the most accurate results. The keen single-pointed tool cuts the metal with

the least distortion. The broad milling cutter forces the metal away, then it springs back and leaves a more or less uneven surface in every case.

Surfaces can be planed so accurately that little or no scraping is necessary and builders of accurate machines can be found who dispense with the use of the scraper absolutely.

For commercial accuracy nothing excels the surfaces left by the planer in shops where good planing is recognized and the men trained to produce it.

Work that Should be Planed

Generally speaking, all broad flat surfaces and particularly the parts having sliding surfaces, where pieces are bolted together for alignment and all parts requiring an accurate surface. This includes all work such as:

Locomotive
- Frames
- Cylinders
- Shoes
- Wedges
- Driving boxes

Printing Press
- Tables
- Frames
- Bearings
- Bases, etc.

Laundry
- Frames
- Mangle chest
- Legs, etc.

Engine
- Steam chest
- Valves
- Frames
- Pillow block
- Connecting rods

Rolling Mill
- Guides
- Frames
- Bearings
- Keyway in shafts
- Tables

Wood Working
- Saw tables
- Frames
- Knife arbors
- Knives
- Bases, etc.

Textile
- Frames
- Guides
- Bearing stands
- Legs, etc.

Electrical
- Motor bases
- Frame segment

Forging
- Dies
- Guides
- Arches
- Header frames
- Bases, etc.

Machine Tools
- Beds
- Tables
- Carriages
- Rails
- Slides
- Knees
- Columns, etc.

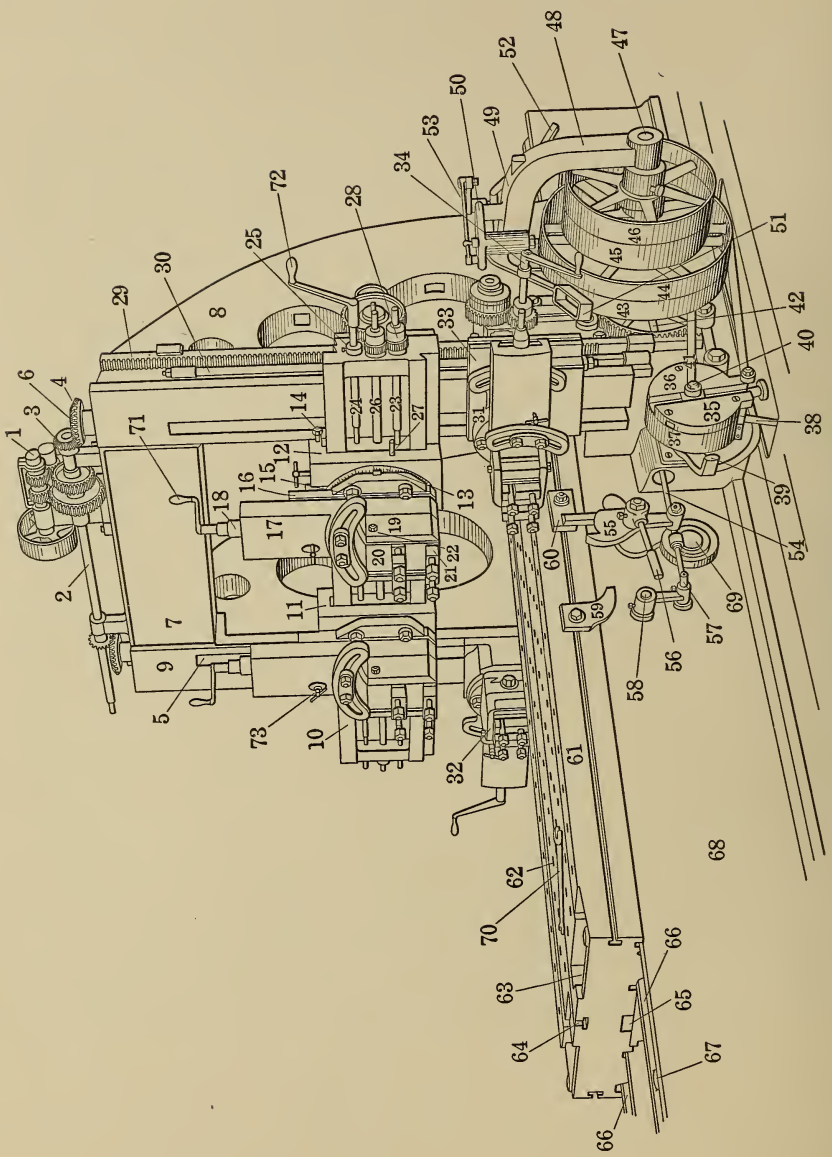


FIG. 2.—Principal parts of planer.

As it is convenient as well as necessary at times to know the names of the various parts of a planer, the principal parts are shown in Fig. 2.

Also work that is long and thin, which must be free from chatter and which cannot stand the distortion due to local heating, should be planed. The planer tool distributes the heat evenly and rapidly and does not distort the work. The slab type milling cutter leaves the surfaces low where the cut stops and starts and also heats the work directly under the cutter so as to distort it, often disastrously.

Principal Parts of a Planer

1. Elevating device for raising cross rail.
2. Elevating shaft.
3. Elevating bevel pinion.
4. Elevating bevel gear.
5. Elevating screw.
6. Nut to adjust rail.
7. Arch.
8. Right-hand housing.
9. Left-hand housing face.
10. Cross rail.
11. Left-hand saddle.
12. Right-hand saddle.
13. Saddle graduations in degrees.
14. Saddle gib.
15. Saddle binder bolt.
16. Harp or swivel.
17. Down feed or tool slide.
18. Micrometer collar.
19. Clapper box.
20. Tool-block.
21. Tool-block clamps.
22. Tool block taper pin.
23. Rail or feed screw for right-hand saddle.
24. Rail or feed screw for left-hand saddle.
25. Micrometer collar for cross feed.
26. Feed rods for both down-feed slides.
27. Lever for engaging down feed.
28. Trigger or ratchet gear.
29. Feed rack for rail and side head.
30. Side head screw.
31. Right-hand side head.
32. Left-hand side head.
33. Side head saddle.
34. Handle for raising and lowering side head.
35. Feed friction.
36. Friction front flange.
37. Friction band.
38. Pawl for friction band.
39. Friction stop.
40. Friction block for regulating feed.
41. Friction link to segment.
42. Segment gear for feed rack.
43. Loose pulley for cutting belt.
44. Tight pulley for cutting belt.
45. Tight pulley for return belt.
46. Loose pulley for return belt.
47. Pulley shaft.
48. Over arm to support shaft.
49. Cam bracket.
50. Cam for shifting belts.
51. Belt arm for cutting belt.
52. Belt arm for return belt.
53. Vertical rock shaft.
54. Link tumbler to vert. rock shaft.
55. Tumbler.
56. Tumbler handle.
57. Safety locking device.
58. Rock shaft to shifter on left side.
59. Front dog.
60. Rear dog.
61. Table or platen.
62. Table stop holes.
63. Table pockets.
64. Tee slots.
65. Table rack.
66. Vees or ways.
67. Oil roller.
68. Bed.
69. Bull wheel shaft.
70. Wrench for all bolts.
71. Wrench or crank handle for down feed.
72. Wrench or crank handle for rail screws.
73. Slide binder bolt.

Planers may be divided into two types according to the way in which they are driven. The spur gear drive is the most common but there are many worm gear or spiral drive in use. In the former the power is transmitted from the driving belt, through an intermediate shaft to a large or "bull" gear which meshes in and drives the rack under the planer table as shown in outline in Fig. 3. In the spiral type the drive is through a worm which is set at such an angle as to mesh into the rack.

Larger planers have a further gear reduction, using a fourth shaft, as shown in Fig. 4, this being known as the four-shaft drive.

The size of a planer is given as the largest piece of work that can be planed on it. A $36 \times 36 \times 8'$ planer means one that will plane a piece $36''$ wide and $36''$ high with a table that will plane a piece $8'$ long,

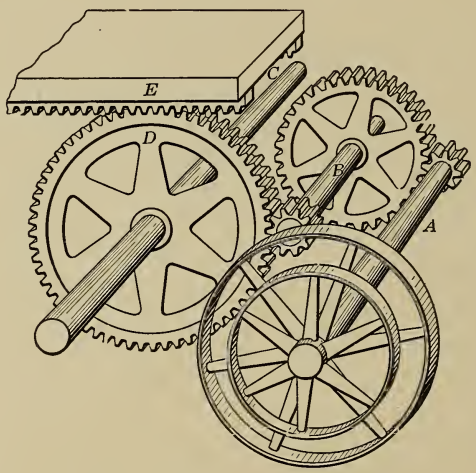


FIG. 3.—How a planer is geared.

this being the length of the table between pockets. Some special planers are made which will plane wider than they are high and are called widened planers but they are usually made with the height and width the same, which is standard.

Small and medium sized planers are usually equipped with one tool head but larger planers usually have two on the cross rail and often one on each side of the housing below the cross rail, known as side heads. These are used to plane down the sides of the work and for making undercuts. They allow the top and sides to be planed at the same time. Their use is increasing as their time saving possibilities become known.

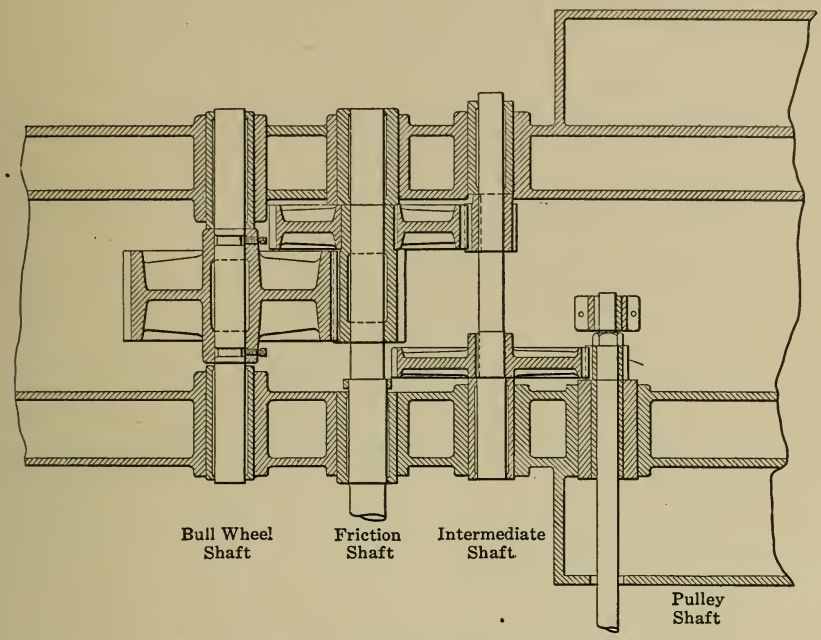


FIG. 4.—Four-shaft drive for 62x62 planer.

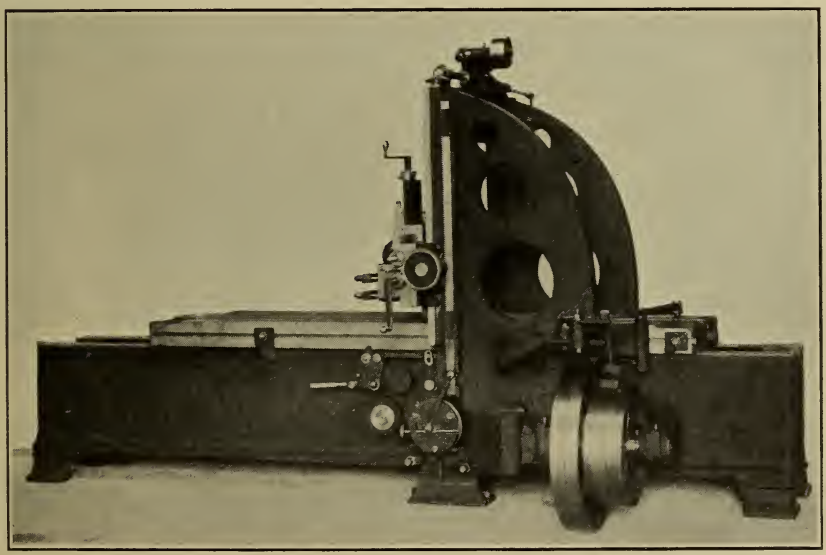


FIG. 5.—Parallel drive.

It is sometimes desirable to have the planer set parallel with the line shafting instead of at right angles as is usually the case. This is accomplished in two ways, as shown 'n Figs. 5 and 6. The first shows the usual method while the latter gives an application of the Almond quarter turn coupling, which allows the regular planer to be used. This is good for small planers.

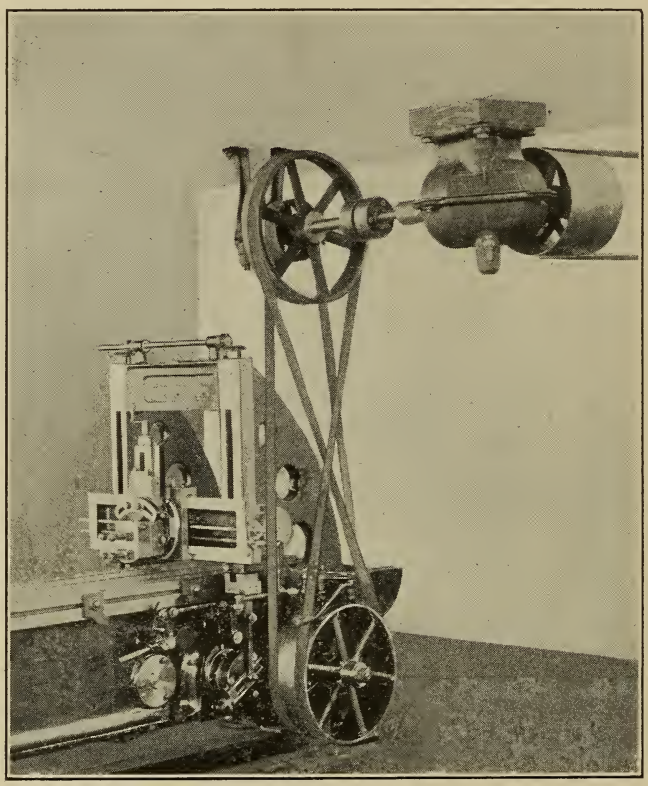
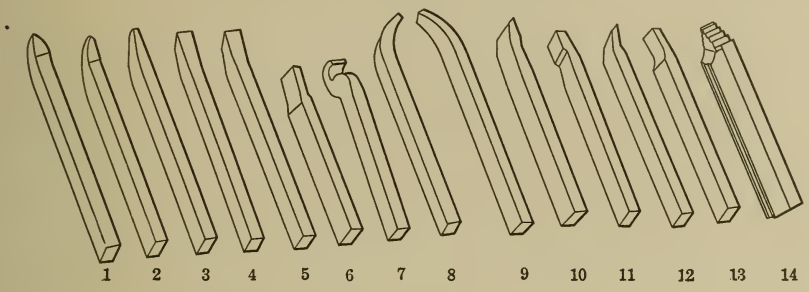


Fig. 6.—Right-angle drive.

Tools for the Planer

While every shop has its own peculiarities as to the shapes and sizes of tools, the collection shown in Fig. 7 shows a set of tools which are recommended by planer builders for general work. Each tool is numbered so that its particular usefulness is known by its name given below.

Fig. 8 is a tool for sizing out a slot such as are cut in planer tables and similar places. The cutting portion is a hardened steel button of the right diameter to give the correct width to the slot. This fits into a hole in the end of the tool holder and is held in place by the rod, having a mitered end for the



PLANER TOOLS.

1. Right-hand rougher.
2. Left-hand rougher.
3. Round nose.
4. Square nose.
5. Square nose.
6. 3/8-in square nose.
7. Gooseneck finisher.
8. Right-side rougher.
9. Left-side rougher.
10. Right-angle or side tool.
11. Left-angle or side tool.
12. Right-angle tool.
13. Left-angle tool
14. Tool for roughing out steel rack.

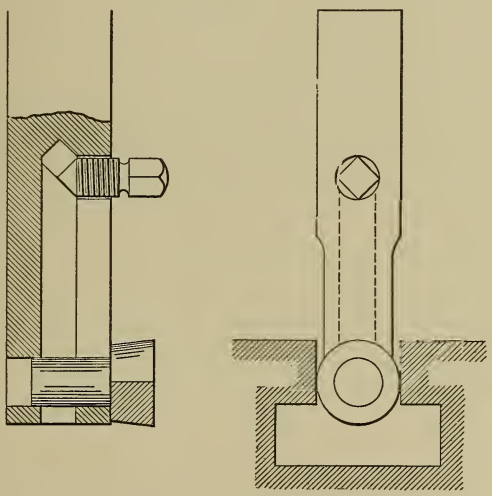


FIG. 8.—Tool for sizing slots.

set screw, to bear against and force the rod against the tool. When this tool dulls, it is only necessary to slack up on the set screw and turn the tool so as to bring a new surface into position. This restores its size and can be done a great many times.

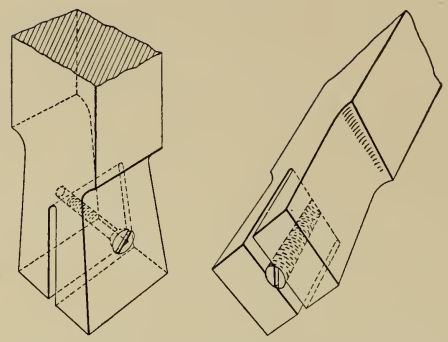


FIG. 9.—Other forms of sizing tools for slots.

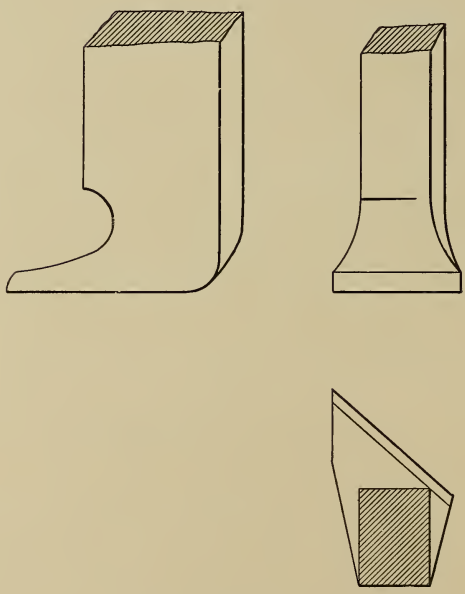


FIG. 10.—Finishing tool.

Another form of tool for this same purpose is shown in Fig. 9. It is a plain tool with the end sawed up as shown with a small, headless screw tapped into one side. This spreads the points as the corners wear and keep it to size. It can be used to plane into a much shallower T slot than the round tool. These tools are also made with a small cone head screw in the end for spreading the points.

Fig. 10 shows a finishing tool, for cast iron which is advocated by some on account or its shearing cut, the cutting edge having the long beveled face *A* at about 45 degrees to the shank as can be seen from the cross sectioned portion. Fig. 11 shows how this is modified for finishing steel.

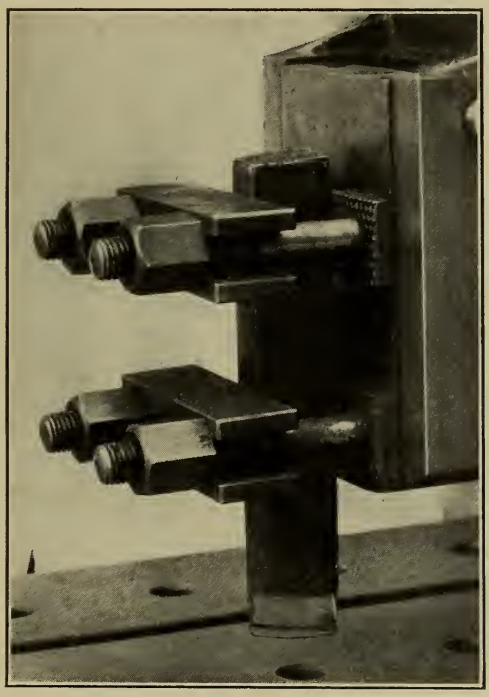


FIG. 11.—Finishing tool for steel.

The tool shown in Fig. 12 is made especially for Planing the V's on the lathe beds, but various modifications of this can easily be made to suit other work. This is one of the tools in which the cutting edge is brought back behind the back edge of the shank, in order to avoid all digging in, which occasionally happens when this is not done. With the cutting edge behind the bottom of the tool shank it is easy to see that any springing of the tool must throw the cutting edge away from the work instead of digging into it.

Lathe builders also use a modification of this as shown in Fig. 13, having a backward or negative rake; some using one first and some the other. In either case any slight chatter, left by the first tool is taken out by the second on account of the different angle the cutting edge makes with the work.

A similar tool is the radius cutter in Fig. 14, the steel cutter having the radius desired. A hollow radius is also shown, both being in the form of spring tools.

Figs. 15 and 16 show two forms of adjustable tools; the first is somewhat similar to the one shown later as being used for planing the index block holders. But in this case the tools are fastened rigidly in the holder *A* and the operator is

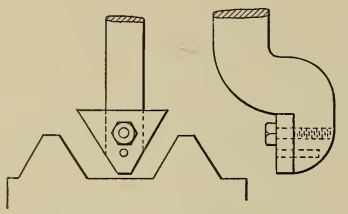


Fig. 12-Tool for Finishing V's

Fig. 13

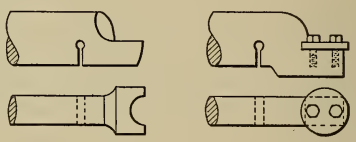


Fig.16-Radius Tool.

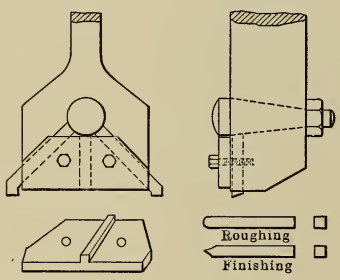


Fig.15-Double Tool Holder

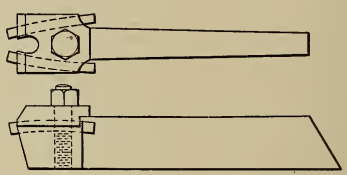


Fig.14-Tool for Planing Tongues

FIGS. 12–16.—Special planer tools.

depended on to raise them out of the cut on the return stroke. The taper pin *B* coming down against the back of the cutters *C* forces them out and, of course, increases the distance between the cutting points. The details make the construction of the tool very plain.

In Fig. 16 this is reversed in order to bring the cutting edges closer together as the blades are extended from the shank. This is for use in planing tongues or any other raised portions which are to be a certain width, and in this case it is only necessary to center the tools so that the tongue or rib will come in the correct position and bring the tool down over the work, as it cuts both sides at once and sizes it correctly.

When there is a tendency for the tool to dig into the work, either from the softness of material or streaks or spots of hard metal it is a good plan to make a tool that will have the cutting edge behind the hinge pin in the clapper box.

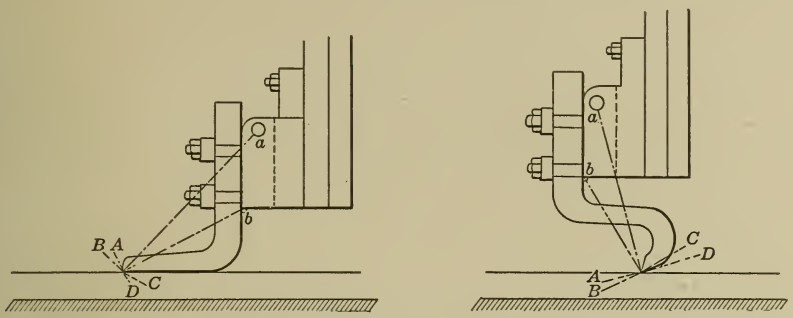


FIG. 17.—How a tool springs into or out of a cut.

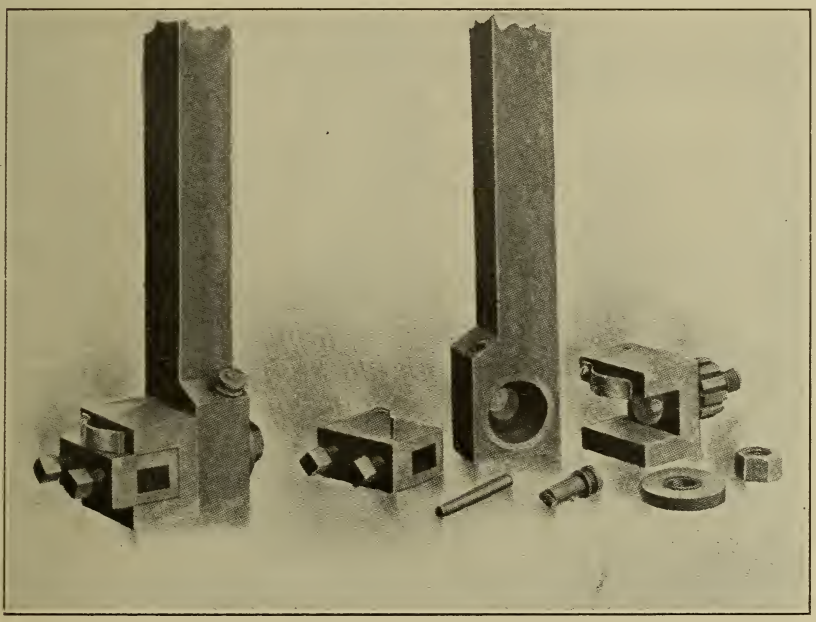


FIG. 18.—Whalen patent planer tool.

Fig. 17 shows the tendency of the tool to swing into the work when the cutting point is ahead of the pin and away from it when it is behind the pin. The dotted curves show the movement of the point of the tool under cutting action.

Fig. 18 shows a new patent combination planer tool which has many ad-

vantages. This tool has an apron and tool block the same as a planer as well as a turret movement that allows the tool to be revolved in the end of the shank. This enables it to cut in any position, across the surface, down the sides and to do right- and left-hand undercutting.

The turret or tool holding head can be set in any position by loosening the nut in the rear and screwing down the thumb nut on the side. This withdraws the locking pin, allowing the head to be turned in any position. This tool does away with lifting or dragging on the return stroke, on side work or undercutting. It is particularly useful for planing slots in the side of work, where a side head cannot be used to advantage.

Undercutting Tool for the Planer

Two undercutting tools with relief movements for the planer are illustrated in Fig. 19. The holder for the tool has a shank passing up through the lower

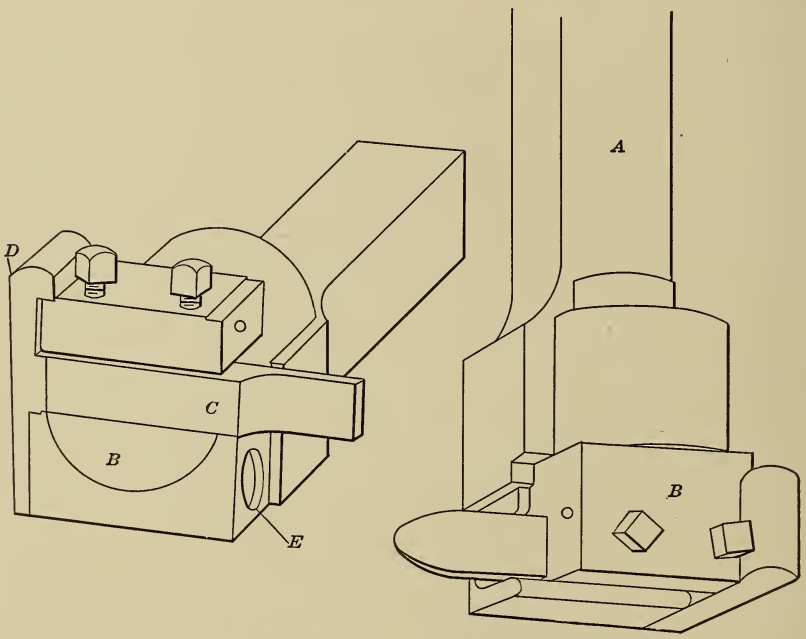


Fig. 19.—Planer undercutting tool with relieving motion.

end of the heavy steel body and the tool block is adapted to rock on the return stroke sufficiently to relieve the cutting point.

The tool holder proper is represented by Fig. 20, and as there shown, it is provided with a large taper shank which fits the hole bored in the enlarged portion of the bar or square shank, and at the upper end of the tapered bearing

there is a straight thread for the reception of two round nuts which will be seen in Fig. 19. The squared bar or shank *A* for the whole tool, is 2 1/4 inches on a side and the length over all is 16 7/8 inches. The opening in the tool holder is 1 1/4 inches square and the whole affair is a heavy tool designed for severe, everyday service.

The rocking tool holder *B* takes a substantial bearing in the semi-circular seat and during the cut the planing tool bears solidly upon the shoulder *C* at the front of the tool bar, against which it is held by a spring plunger *P*, Fig. 20, that presses against the inner face of the hook-shaped strap *D*. This attachment, by the way, also helps to stiffen the tool under action, as the hooked end

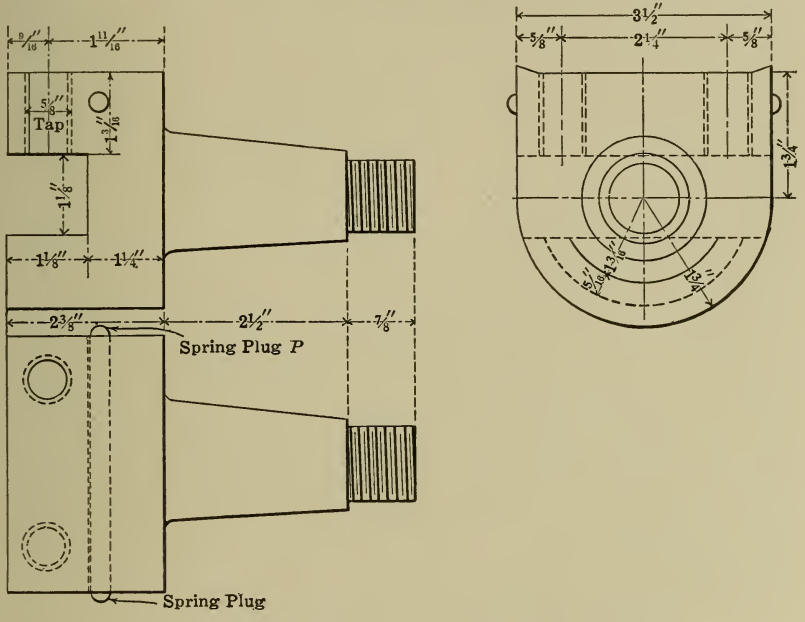


FIG. 20.—Tool holder used in undercutting tool for planer.

then engages the upper corner of the tool holder, as shown in the illustration. Upon the return stroke of the planer, the spring plug permits the tool holder to rock back in its seat sufficiently to relieve the cutting edge.

Of the two tools in Fig. 19, one is shown set right-hand, the other left. Both may be set either hand, however, by simply removing a screw from hook *D* and transferring that member to the other side of the tool bar. The recess at *E* is formed in both sides of the bar and admits a circular boss on *D* so that it may be applied with ease to either side of the tool. There is, of course, a spring plunger at each side of the tool holder so that if operates equally well from either side.

Supporting Overhanging Tools

It is one of the first principles of planing or, in fact, of almost any machine work, that the cutting tool should be supported as rigidly as possible, and the overhang reduced to the lowest point. There are many cases, however, where on account of projections on the piece to be planed it is absolutely necessary to have the cross rail of the planer at a considerable height above the surface to be planed, in order to clear this projection. This means overhang in spite of everything that can be done, and to offset this the planer tools have long,

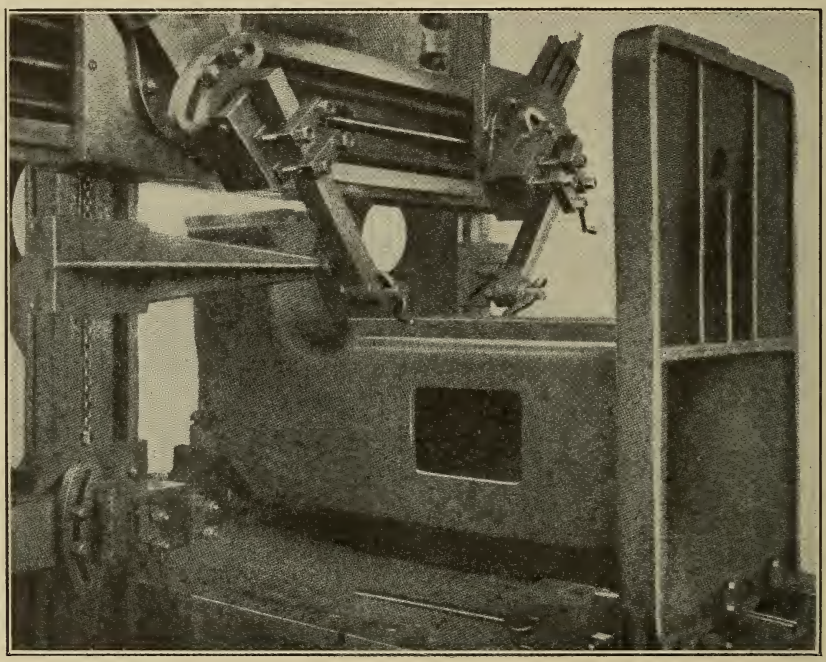


Fig. 21.—Supporting overhanging tools.

heavy shanks so as to be stiff as possible. Even with this, however, it usually prevents the taking of a good cut on account of the spring of the tool, and as a cure for this disease the plan shown in Fig. 21 is suggested. This is a strongly ribbed arm which projects from the housing and carries an adjusting screw in the end so as to make a positive support for the shank of the tool, or the tool holder in this case, as close to the cutting point as is possible. While this is not as good as though the entire overhang could be avoided, it is a decided improvement over the usual method of support and allows a fairly good cut to be taken, and also makes it possible to secure a more accurate job.

This is a large piece of work, and while it may not be possible to adopt this particular form of tool support in all cases, it gives an idea which can be adapted to suit many conditions. In this case it is connected to the elevating screw of the cross rail so that it can be easily moved into any desired position. One of these on each side makes it possible to use two cutting tools and get good results from them both.

Stops and Other Planer Furniture

Several clamps or stop blocks are shown in Figs. 22, 23 and 24, the first two being the more common and easier to make. They are made of square-machine steel with the end turned down to fit the round holes in the planer table

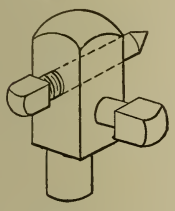


Fig. 22

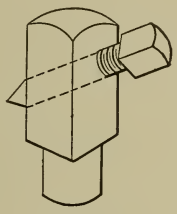


Fig. 23

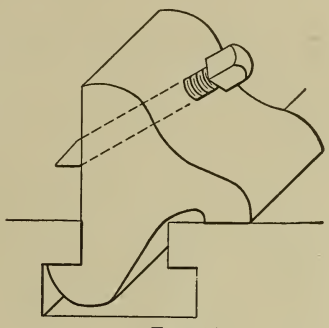


Fig. 24

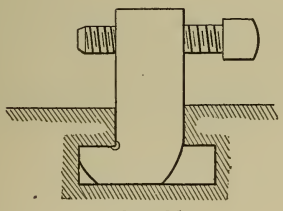


Fig. 25

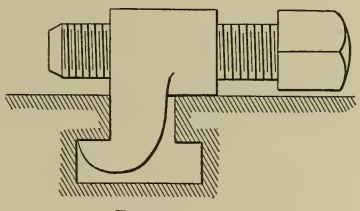


Fig. 26

Figs. 22–26.—A group of screw stops.

and the square portion above is tapped for one or two set screws according to the work it is designed for. If arranged for two screws as in Fig. 22, it is particularly useful in a corner as one set screw can go against each side of the piece. It also gives practically two blocks as in some cases it is much more convenient to have the screws high or low as the case may be.

The blocks and fixtures shown in Fig. 27 will handle a large variety of work. The blocks *A A A* are planed to fit the T slots and hook under the slot as with Figs. 24 to 26. The surfaces above the table must be planed parallel to the

portion that fits the slot and with the faces all the same distance from it. These, with the screw blocks *B B B* shown in the next slot make an excellent method of holding a large variety of work and, if the plain blocks are square, there is no need of testing the work for parallel when clamping it in place. The bolts at *C C C* screw into special nuts which fit the T slots and prevent turning.

The stops at *D D D D* are plain pieces of machine steel with the ends turned to fit the holes in the table. These should be made in two or three heights but it is seldom advisable to use them over 6 inches high, while 2, 3 and 4 inches will be found more useful in most cases. In the positions shown they reinforce each other by using a block between, so that the work is being held against the cut by four screw stops instead of two.

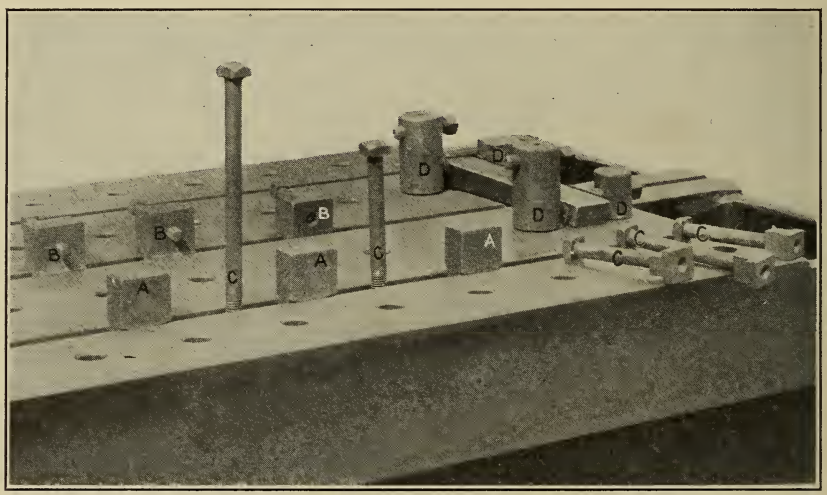


FIG. 27.—Work-holding blocks, bolts and stops.

Fig. 23 is very similar to the other except that the set screw is at an angle which will be found very useful in many cases as it forces the work down on the table. Figs. 24 to 26 make very rigid clamps and when work is held between a number of these and a substantial angle plate on the other side, it is very similar to a planer chuck as in Fig. 28, and the angle of the screw in Fig. 9 is perhaps excessive in the sketch, but it will naturally vary with the work in hand.

Parallel strips are a necessity among planer furnishings, but instead of making them of cast iron and having them carefully planed up as formerly, a number of shops are using cold drawn steel bars for this purpose. By using a little care in the selection of these and measuring them so as to secure uni-

formity, it is generally possible to buy the material practically as accurate as the average parallel strip is planed up, and as all that is necessary is to saw them to

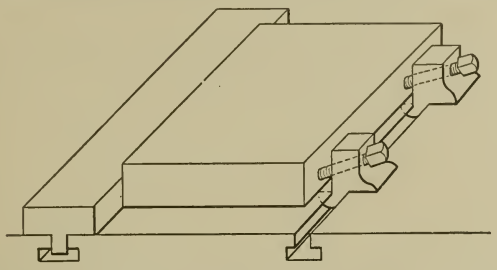


FIG. 28.—Holding work between a parallel and screw stops.

any desired length from the bar, they are decidedly cheaper to make. In order to avoid having an extremely large number of parallels, it is quite customary to

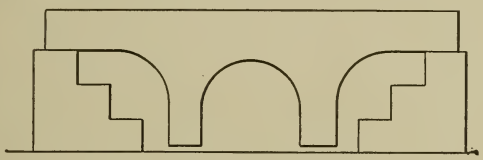


FIG. 29.—Using blocks to raise work from the table.

plane some of these in steps as shown in Fig. 29, so that they will accommodate a number of different heights.

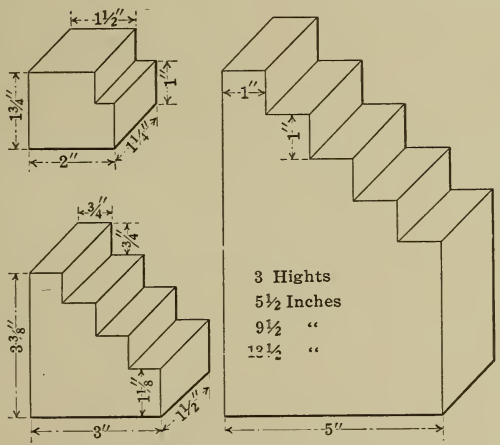


FIG. 30.—A set of useful clamping blocks.

The best proportion for these must be determined by each shop according to its own particular work, but a suggestion may possibly be had from Fig. 30.

The first shows a small parallel block which will give five different heights, varying by quarter inches from 1 to 2 inches, inclusive, according to the way in which it is used.

Sets of clamping blocks made along these lines will be found very convenient on any planer, the sizes being varied according to the work to be done. This will

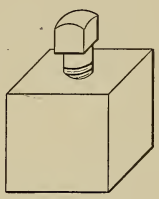


FIG. 31.

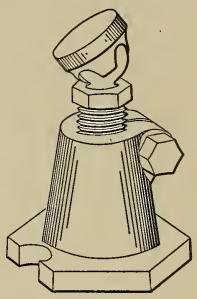


FIG. 32.

Two kinds of planer jacks.

help to keep the usual blocks of wood and other unsightly things out of the shop. The block shown at the right is made in three heights, varying from 5 1/2 to 13 1/2 inches, the combination taking in almost any work that comes along in the average shop.

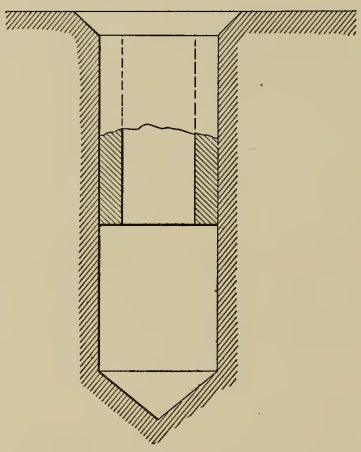


FIG. 33.—Plug for planer-table hole.

Fig. 31 is a cheap form of planer jack which consists simply of a block having a hole tapped in it for the set screw shown. Every planer should be supplied with all the fixtures that it needs, and a goodly stock of these small set screw blocks or jacks, will more than repay their cost. A man can very easily spend

more time hunting around for the right block than a number of these would cost, and these save time on practically every job that comes to the planer.

The larger planer jack shown in Fig. 32, which can be bought of any good machinist's supply house—will be found useful.

Another convenient fixture around the planer is the plug for the holes in the planer table shown in Fig. 33. This is easily made of bar steel and is counterbored for lightness. A set of these for each planer prevents the holes getting clogged up with chips or dirt or of getting down on inside of bed when the holes go clear through the table. They are a fairly loose fit, leave the table perfectly smooth, and can be readily lifted out with a common horseshoe magnet.

The Strains in Metal

In order to secure work which is true and straight, it must not change shape in any way after the surface is planed. The methods of clamping and especially the strains in the metal itself, must be carefully considered.

When a casting is cooling in the mold, the outside cools first, and strains are set up which sometimes warp the casting or even break it. But even if it comes out straight some strains are there waiting to show themselves when the surface or skin of the casting is removed. This is also true to a less extent with rolled or drawn-steel stock and must be watched by the planer hand who wants to turn out a good job. When the skin is removed, the tension is relieved on the side where the cut is taken and the tension of the opposite side tends to draw the piece into a bow shape. This can be readily seen by planing up one side of a bar of cold rolled steel as, when released, it will assume a decided bow, from the pull of the skin on the side not planed.

This is the reason that, even with heavy lathe and planer beds, we find the best practice is to rough plane both the top and bottom of the bed before any attempt is made to finish the top side. It sometimes seems as though the time of taking the bed off the planer and then resetting it after planing the other side, was an unnecessary expenditure of time and effort. But experience has not only proved that it is necessary for good work, but it also shows that it is good practice to let the work lay for some time between the roughing and the finishing cuts so as to season, or to let the internal strains work themselves out.

If to the strains of the casting is added a strain in strapping the work to the table, the distortion of the work after it is released can readily be imagined.

Good Judgment Necessary

This gives a greater opportunity for the display of ingenuity and real mechanical ability than almost any other machine operation and develops a splendid class of men; and a good planer hand is always in demand.

The methods of clamping the work; the tool to use; the use of gages and measuring devices, all hold the interest of the man and develop good judgment that makes him valuable to himself and his employer.

And the work is correspondingly higher grade.

The holding of work on the table of any machine is more of an art than many imagine. The thrust of the cutting tool should be taken by some sort of a stop instead of attempting to strap the work tight enough to resist the cut. The clamps should simply prevent any lifting movement and they also assist the stops by the friction they create between the work and the table of the machine.

By following this method carefully there will be much less springing of the work than by the other plan. It is very difficult to frame up any set of rules for this work, but the good planer man always bears in mind that the work must not be sprung in clamping it to the table and arranges his clamps accordingly.

Where the work must be clamped at a point which does not reach clear down to the table, a block or support of some kind should be placed between the table and the work under the clamp to prevent springing. Place a block between table and work, then try top of work with an indicator, then after clamping try again to see if blocking, etc., have been pressed down too much by clamping. The use of tissue paper or thin metal is also very common between the work and the table even when the work bears solidly under the clamping points. This localizes the bearing point on the table and avoids all tendency to spring the work when it is strapped down hard enough to hold it securely.

These same precautions must be observed in making fixtures for holding the work. Substantial bearing points must be provided in such positions as to resist the strains imposed by the action of the straps or other clamping devices. With fixtures made properly, the work can be placed very quickly, held securely, and in such a way that it will not be sprung when it is released from the fixture.

If only half the time and study that is devoted to jigs, fixtures and convenient appliances on other machines, was given to the proper ways of handling work on a planer, the saving would be astonishing. By the making of good fixtures two, three, or even four heads can be used simultaneously and with higher speeds and coarser feeds, on account of the increased rigidity. Where the work is difficult to clamp, frequently only one piece is planed at a time, whereas if jigs were made the whole length of table could be filled, saving all the time required for changing tools, gauging, measuring, etc. Work machined this way is also more uniform, easier to fit, and saves time in assembling.

Springing Work in Clamping

Although it seems strange to think of a heavy block of cast iron springing enough to notice from the pressure of the clamping bolts, it is too often the case unless care is taken to avoid it. It can be taken as a good rule not to clamp or

bolt a piece of work any tighter than is necessary to prevent the tool from lifting it and to take the end thrust of the tool by blocks or stops at the end of the piece. It is also used to take as much of the side thrust or tendency of the tool to crowd the work across the table in the same way, and bolt down as little as can be done with safety.

Springing can also be avoided by making sure that the work is supported directly under the strap or clamp, if at no other place, as if this is not done it is impossible to avoid springing the work and it will not be true when it comes off the planer.

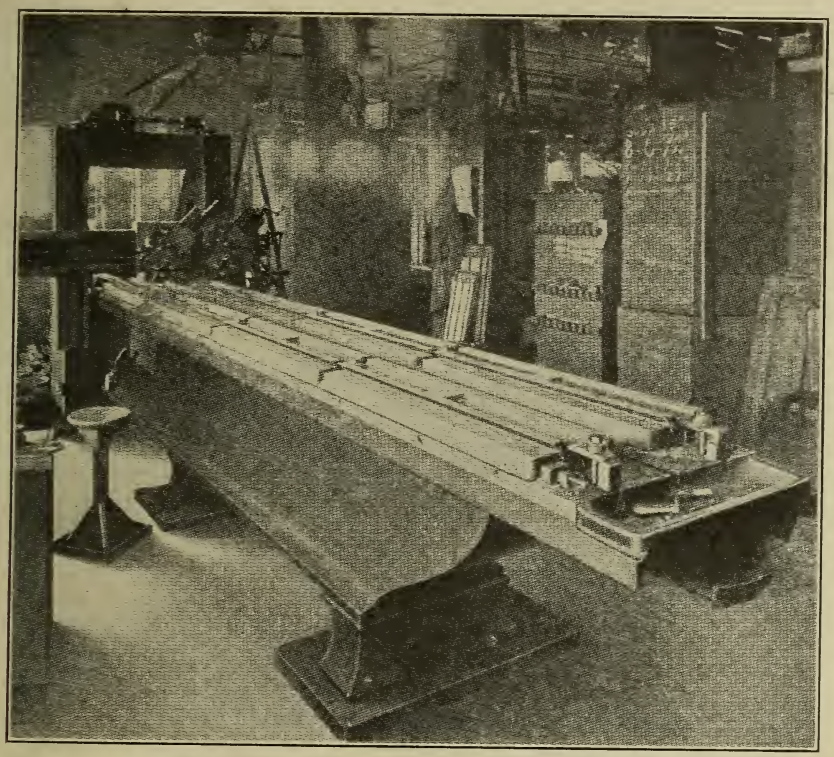


FIG. 34.—Clamping the work down on paper strips.

It is quite common practice to use thin steel wedges or shims on rough castings to get an even bearing between the casting to be planed and the planer bed, using a wedge under four, six, or as many points as required to give a good support. Then when the work has been rough planed on the back side, it is turned over and again supported, but on strips of paper instead of steel wedges.

Paper is very handy in this respect, as it comes quite uniform in thickness and seems to prevent smooth work slipping on the table.

An example of this is shown in Fig. 34, the work resting on paper at six points, three on each side, and two thicknesses are used at each point in this case. This insures a good, even bearing, and the work is held down by clamps at the end, the thrust being taken by the end blocks or stops, two varieties of clamps being shown on this job. This also shows how work is grouped or strung along the table, so that a long cut can be taken and the cost per piece materially reduced. The ends which join each other are clamped by a plain clamp and only room enough for the bolt allowed between.

Holding Work For Planing

In many places the only clamp is a plain flat bar with a hole in the center for the bolt, or perhaps two or three holes to allow it to be placed in different positions. This kind of a clamp always requires blocking up at the end away from the work to an amount equal to the thickness of the piece being clamped.

Some of this can be avoided by the use of angle clamps as shown in Fig. 35 and of course the bent end *A* will have to vary in length according to the work in

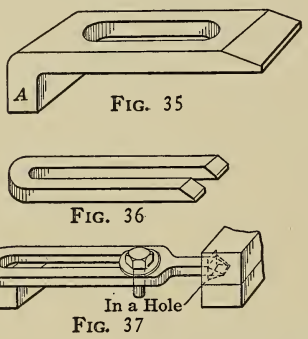


Fig. 35

Fig. 36

Fig. 37

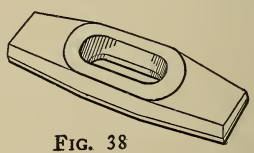


Fig. 38

Figs. 35–38.—Straight and bent straps or clamps.

hand. But a few of these with the end *A* of varying lengths will be found extremely useful in any planing job. Fig. 36 shows a very popular form of strap known as a U or hairpin clamp. It can be taken on or off by simply slacking the nut and does not require the nut to be taken off. Fig. 37 is often used for holding work having a hole cast or drilled into it for the point of the clamp. This leaves the top of the work perfectly clear. These can be made of a variety of shapes and sizes and the clamping point is often bent up or down as the case may demand. The drop forged clamp, as in Fig. 38 is coming into use in many places and is much neater and stronger for its weight, than the old bar clamp.

One of the main things to remember is that in all cases the strap should be as nearly level as possible and the bolt must be as near the work as circumstances will allow. Fig. 39 gives some good and bad ways of using straps.

Parallel strips are also convenient in clamping work to the planer table, as they make good supports for the back end of the strap and also help to line up the work.

The clamping bolts must be as near the work as possible so as to give the advantage of the leverage to the bolt in tightening the work. With the bolt

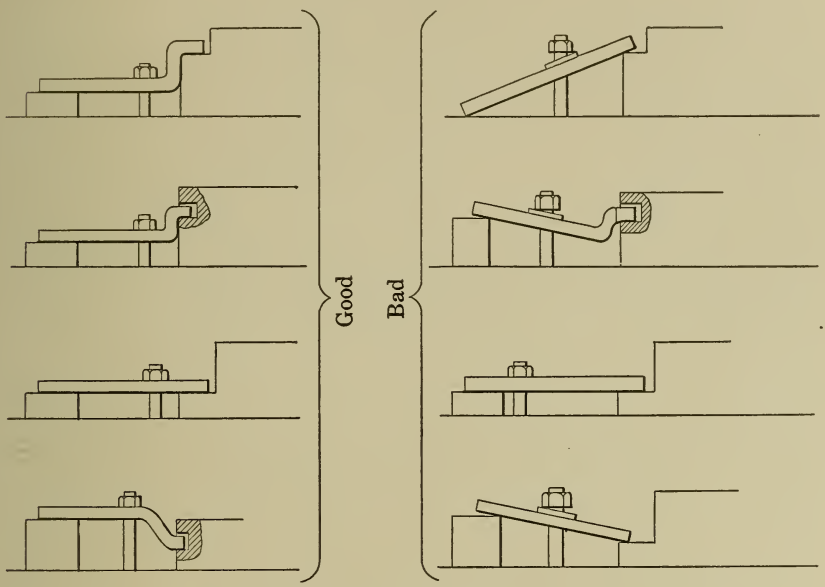


FIG. 39.—Good and bad ways of using straps.

in the middle, the pressure is equal at both ends of the strap, but with the bolt next to the work and the other end of the strap several inches away, the work gets the full benefit of the strain on the bolt. If the case were reversed and the bolt several inches away from the work, the bolt must be strained several times tighter than necessary to get the same pressure on the work.

There are so many ways of holding work to the planer table that only suggestions can be given as this is one of the cases where good judgment is worth money to the planer hand. The man who can size up a piece of work and know the best way to clamp it without springing it, is the kind that all good foremen are looking for.

It often happens that the use of parallel strips directly on the planer table makes it easier to strap the work as the strips give good bearing points beneath

the points of the clamps and at the same time hold the work level. Care should be taken however to provide an end stop of some kind, perhaps a small angle plate or a cross piece held by plugs or pins in the planer table.

The surface gage is the most useful tool for a planer hand next to his rule or scale and every planer hand should have at least one of good substantial

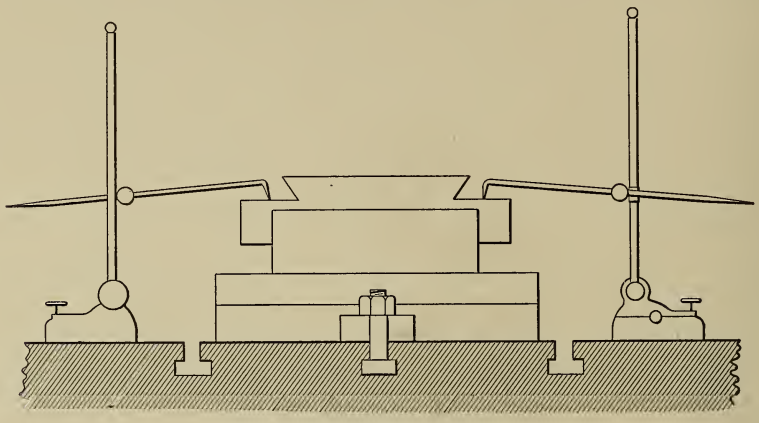
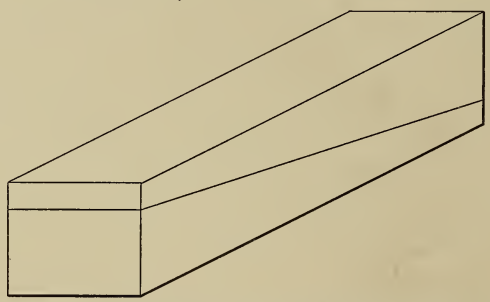


Fig. 40.—Using the surface gage.

make with easy adjustments. Fig. 40 shows one of its uses. The piece of work shown is a slide for some machine and it is important that the two sides should be an equal thickness, or height from the table. So the surface gage is set to just touch one side and then transferred on the planer table to a similar



Fg. 41.—Two similar taper pieces being planed on each other.

position on the other side as shown by the dotted lines. This shows at once whether both sides are alike or not and how much one differs from the others.

In planing taper work, one end must be blocked up to the required distance so that when the top is planed parallel with the table, the piece will be of the required taper. This can be done in the chuck or on the table, according to the

work and the facilities at hand. When two similar pieces are to be planed, they can be placed one on top of the other, as shown in Fig. 41 and both planed without fixtures or blocking up.

If many pieces are to be planed alike, it will pay to make strips of the right taper to put under the work so that it can be set without any measurements whatever. In many cases these taper strips are made part of a holding fixture and the work simply placed in the fixtures which both locates them at the right angle and holds them against the action of the planer tool.

Small work is frequently held in planer chucks, which bolt to the planer table and may have either a plain or a swivel base. The main precaution in cases of this kind is to prevent the planer jaws cocking up as they are tightened

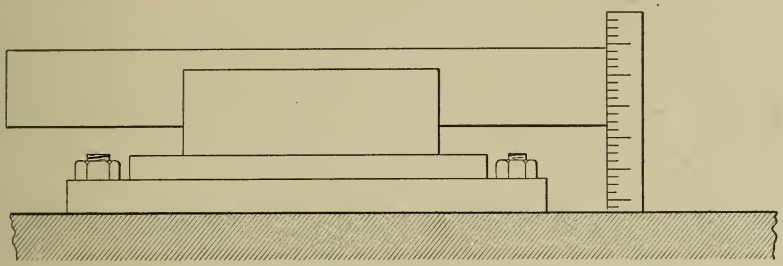


FIG. 42.—Testing work in chuck.

and throwing the work out of true with the base of the chuck. Even the work itself has a tendency to be forced up as the jaws are tightened, so that it is always best to tap the work down with a soft hammer as it is being tightened in the chuck.

Where the work projects beyond the jaws of the chuck, it can be very easily leveled by measuring the distance from the work to the table with either a rule as in Fig. 42 or a surface gage as in Fig. 40. Or the chuck itself can be tested by clamping or laying a steel rule in the chuck and measuring to the under side of the rule in the same way.

Where the work is thinner than the jaws of the chuck are high, parallel strips are used under the work, both to raise it so that the planer tool will clear the chuck jaws and to make it easy to level the work.

HOLDING THIN WORK

It is comparatively easy to clamp heavy work to the planer, and the most difficulty is experienced when it becomes necessary to plane thin pieces of work, as shown in Fig. 43. There are a number of ways in which this can be done, this being only a suggestion which can probably be modified to advantage in

many cases. As in all other work it should be the aim to take the thrust of the tool by stop block and only use the clamping device for holding the piece level on the planer table. In this case the piece *A* has a sharp or serrated edge and the pieces *B* are sharp pointed tool steel so that the point will be forced into the

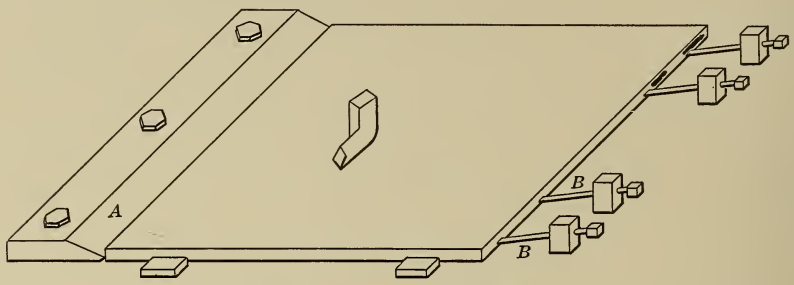


FIG. 43.—Holding a thin plate.

work by the set screw in the block at the end. If the set screws have cupped points the pieces *B* should be sharp at both ends, but if cone-pointed set screws are used, it is, of course, necessary to have one end of the pieces cupped to receive it.

Figs. 44, 45 and 46 show other ways of holding work that is comparatively

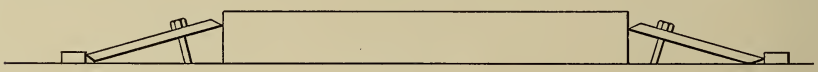


FIG. 44

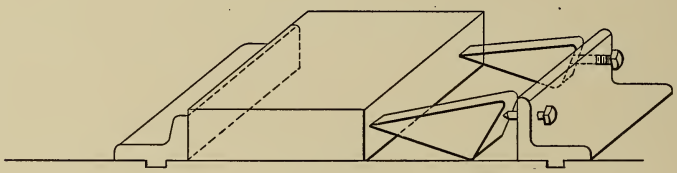


FIG. 45

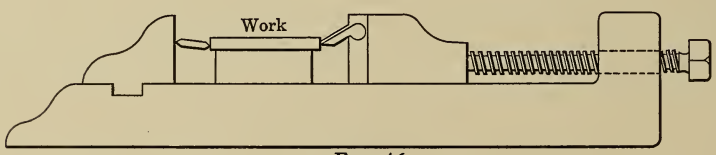


FIG. 46

FIGS. 44–46.—Clamping devices.

thin. The first is very common but not especially desirable. If, however, the straps bear as near the top of the piece as possible, it answers very well.

Fig. 45 shows a plan used to take the place of a chuck. The angle plates have tongues fitting the planer table slots, and are, of course, bolted down.

Set screws are provided in either or both of these, and in this case a three-cornered clamping block is used for the holding down. The set screw bears against heavily countersunk spots in the upper corner, the corner next to this rests on the table and makes a fulcrum, while the long end grips the work and has a downward movement which tends to hold the work in place. Fig. 46 is another and somewhat similar plan for holding thin work; the jaw at the right has sort of hinged gripping jaws which always tend to hold the work down. The plan of mounting thin work on a block as in this case has advantages at

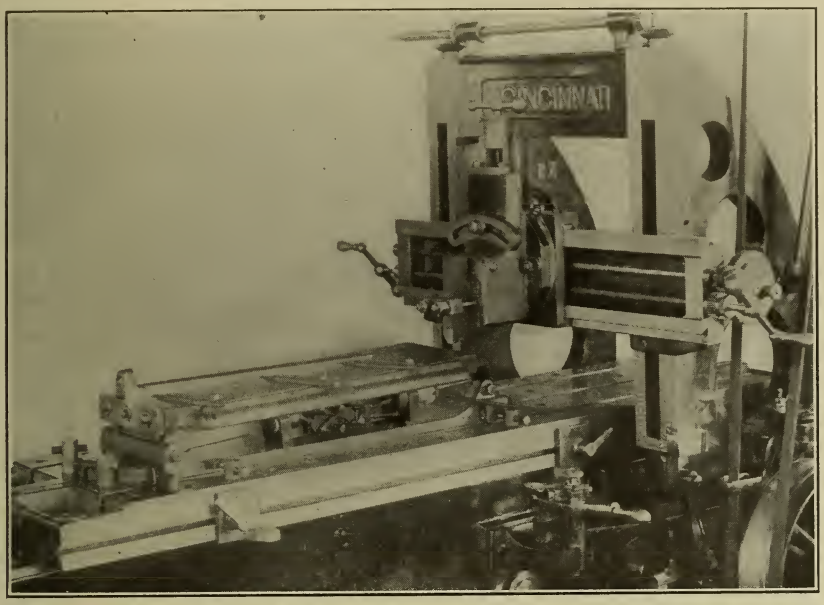


FIG. 47.—Using magnetic chuck for planing taper gib—chuck swung up to right taper.

times, but unless the support comes very close to the edge there is apt to be a bending tendency to the piece and it will be planed thin in the middle.

On some classes of thin, light work it is possible to use the magnetic chuck to advantage. In this case care must be taken to take the end thrust of the tool by positive stops or by so arranging the work that it does not depend entirely on the grip of the magnetism on that piece alone. An example of this is shown in Fig. 47. Makers of the chucks can give many valuable points in this.

PLANING FIXTURES

When a man has only one piece to plane he must devise some cheap, temporary fixture, usually blocking of some kind, to hold it unless supplied

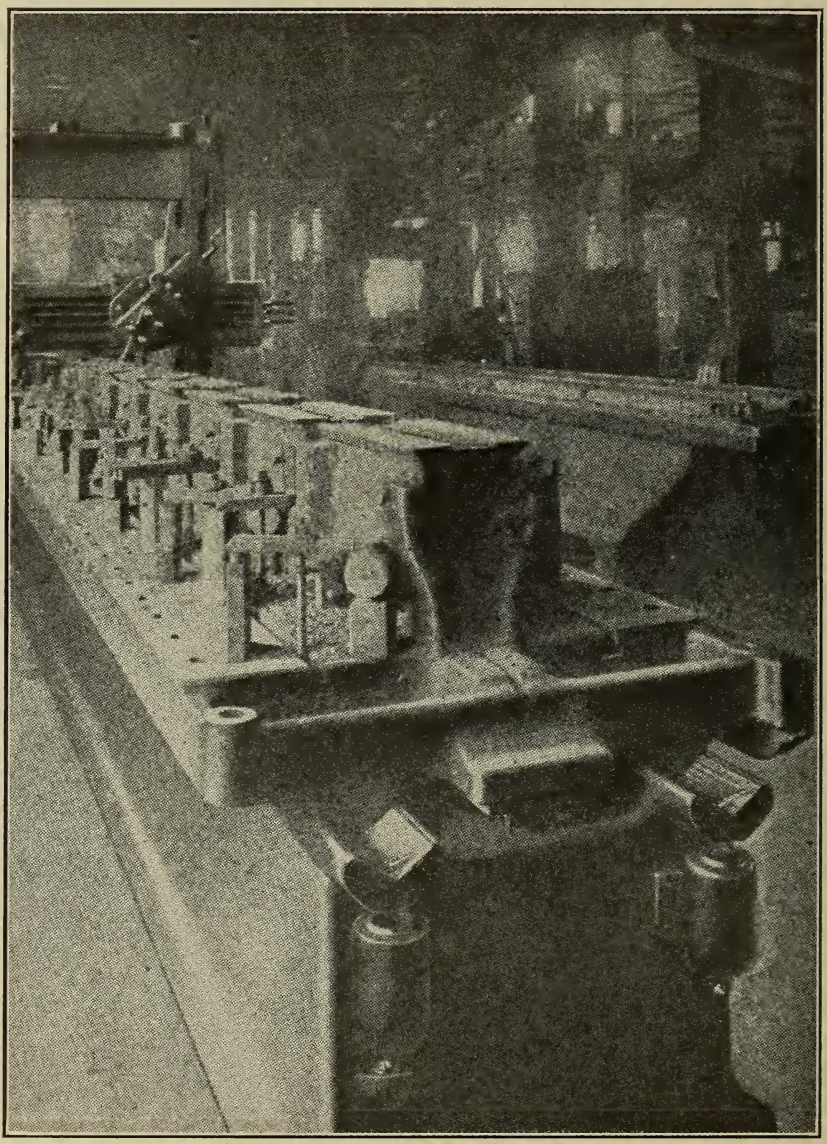


FIG. 48.—A string of planer fixtures.

with the planer equipment previously described. This often means quite a task if the piece is irregular in shape. But when a quantity is to be made it is necessary to make some sort of jigs or fixtures for holding them correctly and firmly so they can be readily put in place or taken down, if the cost of planing is to be reduced as it should. It often happens that it takes almost as long to put a piece on the planer properly as it does to plane it after it is in place; and as this setting time is not reduced by increased cutting speeds we see the importance of reducing the time for chucking or clamping.

Fig. 48 shows a string of milling machine knees held in fixtures that support the front end. These fixtures fit the T-slot of the table and clamp the front end of the knee between the side set screws, while the lower ones at the angle adjust the height so as to make the piece level. The side straps hold the work down by clamping the screw projection against the block underneath. At the sides of the knee toward the back are the double screw stop blocks, one of which can be seen under the side strap. These fit into the table and have set crews running both ways through the square upright. When the lot is large enough, two strings of these are used at once, one on each of the outer T-slots and both heads put to work.

Planing Taper Gibs

A convenient and rapid method of planing taper gibs is shown in Fig. 49. This fixture is a channel provided with a raised center rib for supporting the gib while it is held by the six sharp pointed screws which are inclined so as to

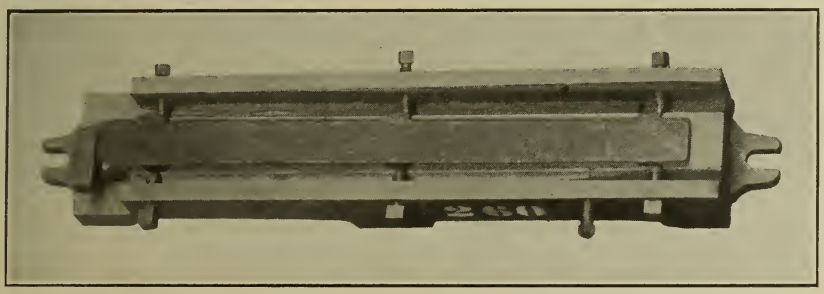


Fig. 49.—Fixture for planing taper gibs.

force it down on the seat. It will be noticed that there are small lugs or projections cast on the gib for these screws to bear against, giving them a good footing.

After the flat sides are planed the gib is held in another fixture as shown in Fig. 50 for planing the sides or narrow surfaces. The further side of the

fixture is undercut to the same angle, the gib being held against this inclined side by the four screws pressing against the four short bearing pieces shown.

FIG. 50.—Fixture for the narrow sides of gibs.

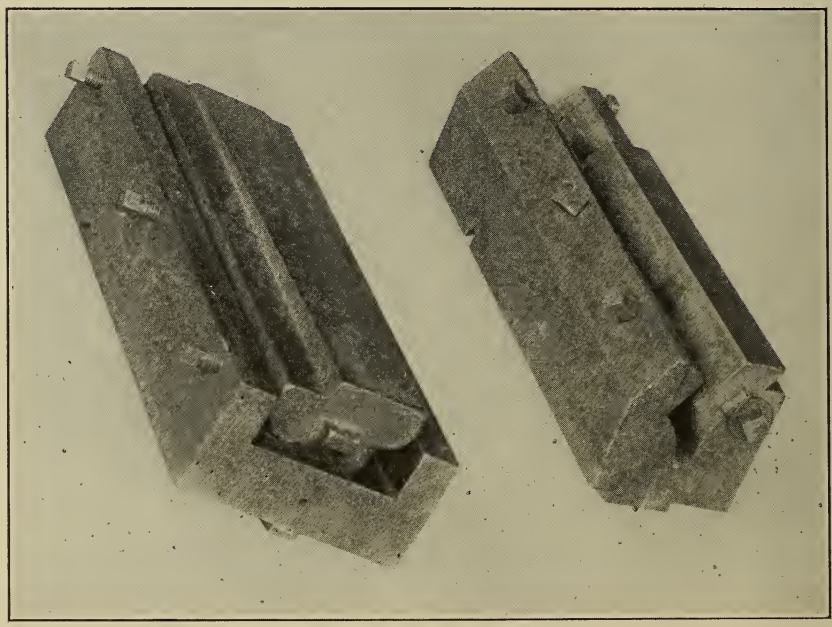


FIG. 51.—Fixtures for planing taper gibs.

This makes it easy to plane off the surfaces at their proper angle without swiveling the planer head.

Fig. 51 shows the fixtures used for holding other gibs and require almost

no explanation. By making the fixture so that the work to be planed will drop into it easily, can be readily fastened, and will be held so as to produce the proper relation between surfaces, the time for setting is largely eliminated and few measurement are necessary.

Fig. 52 shows another method of holding a short gib for planing. If this is used for gibs with double angle it will be necessary to cast holding pieces

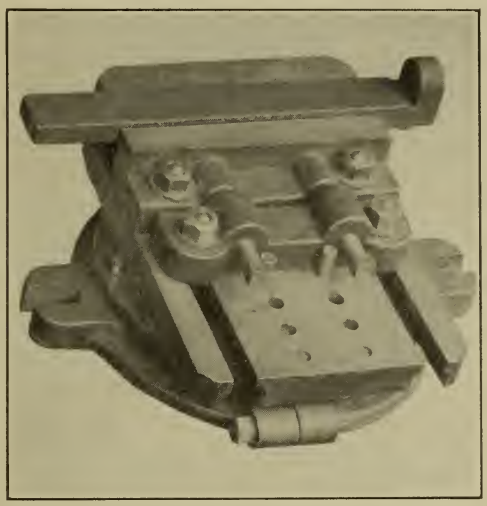


FIG. 52.—Holding a gib in a chuck.

on the gibs so that they can be held squarely for the planing of the flat sides. This is a very substantial form of chuck, the cross piece holding the clamping screws being bolted into the desired position and also reinforced by the two stop pins to prevent all slipping under the cut.

A DOUBLE FIXTURE

A good example of a sensible, time saving planer fixture is shown in Fig. 53. This is for planing the bottom and the key of two saddle nuts at one setting.

The nuts rest on the V's, *A A A A*, being held in the center by the double ended finger clamp *B* and at the outer ends by similar clamps *C C*. These have small jack screws in the outer end to give a support when they are pulled down in the hole by the bolts shown. A similar clamp holds down the other end.

The planed V in which the work rests is parallel with a key on the bottom of the fixture, so that it is only necessary to slip the key into a table slot, against

a couple of stops to take the thrust of the tool, clamp the whole thing to the table by clamps on the projections on the end, and go to work.

The standard steel block *D* fits into a dowel hole in the base and is squared by the two small pins shown near the base of the block. The top of this has a key which is the correct size of the key to be planed and it is also the correct distance from the center of the nut. So, instead of measuring distances, the

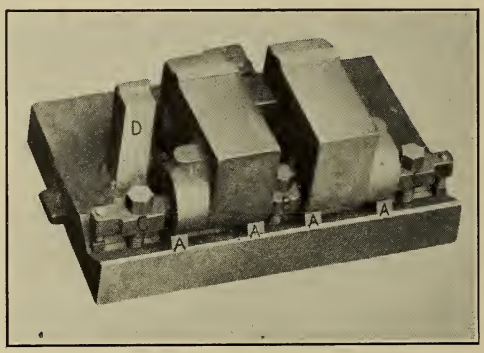


FIG. 53.—A double planing fixture.

tools are set by the steel block and the nuts come out all alike and with the key in the right place. A tool having two cutters as previously described is used for planing the key quickly.

ARMS FOR VERTICAL DRILLS

Fig. 54 shows a string of six vertical drill arms being planed with relation to the spindle holes which have already been bored. The arms are mounted on a mandrel which fits the spindle holes of all six pieces and the mandrel located on the planer table in the blocks *A A A* being clamped by the clamps *B* and the end thrust taken by the cross piece *C* and the end stops *D D*. The planer jacks *E E E* are adjusted up under the lugs of the cross holes *F F* and form supports for the straps *G G G*. By this means the arms are all located correctly with relation to the spindle hole, all the plain and angular surfaces being finished at the one setting and with very simple tools.

STRING PLANING OF MILLER PARTS

Some of the following illustrations will give a good idea of the time-saving possibilities when the work is mounted in large quantities and the tools are gauged, thus saving all the time for resetting each job when done one at a time as well as the changing of the tools.

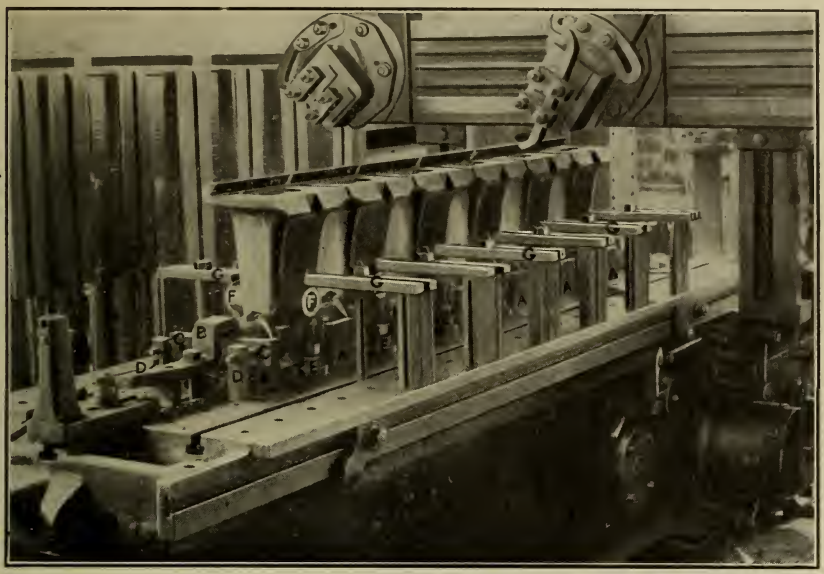


FIG. 54.—Planing a string of driller arms.

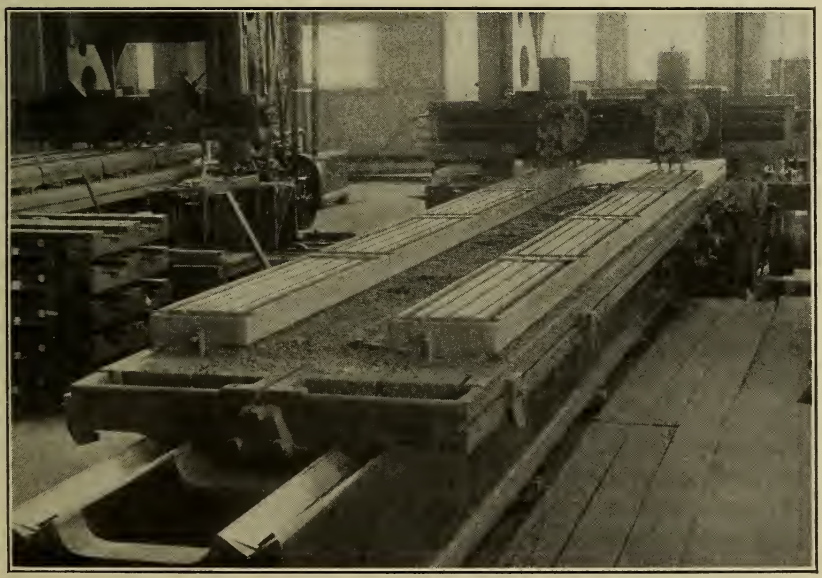


FIG. 55.—Planing a string of miller tables.

Several good examples of string work, or planing a number of pieces at one setting, to save time for changing tools and gaging as would be required for each piece if done one at a time, are shown herewith.

Two rows of four each, eight milling machine tables in all, are shown in Fig. 55. This shows how they are held against small angle pieces located in the outside T-slot of the planer table, these pieces fitting the angle of the dovetail slide on the lower part of the tables being planed. The work is forced against these by the small pieces which convey the pressure from the screw stops. The thrust of the tools is taken by the stops at the end.

FIG. 56.—Planing saddles for taper gibs.

Six tools are seen at work at one time putting in the table slots.

The next illustration, Fig. 56, shows twelve milling machine saddles being planed for the taper gibs. The spacing and locating blocks which can be seen between the two strings of work, fit into the center T-slot and are made at the right taper with the table slot so as to throw the saddles around as can be seen. The way the work is held down shows practical methods and it will be noted that in this case it was found better to use the heads of the screws in the screw stops. The method of bridging the pocket in the end of the planer table to get a good bearing for the strap and the clamping piece may also be worth remembering.

Another method of handling work of this kind is shown in Fig. 57. A string of these are then lined up on the planer table with the center lines in line with each other, and the left or bearing side of the dovetail planed to the correct angle.

On the other side of this bearing is the taper gib, and in order to plane a string of these it is necessary to have each saddle swung just the right amount, as shown. In planing the straight side the whole string was squared up by the plate shown at the back, which was then turned one-quarter way round in order to present the side which was exactly square with the planer. This plate is now swung into the position shown and the edge presented to the work is at the same angle from the square as the taper of the gib. Backing

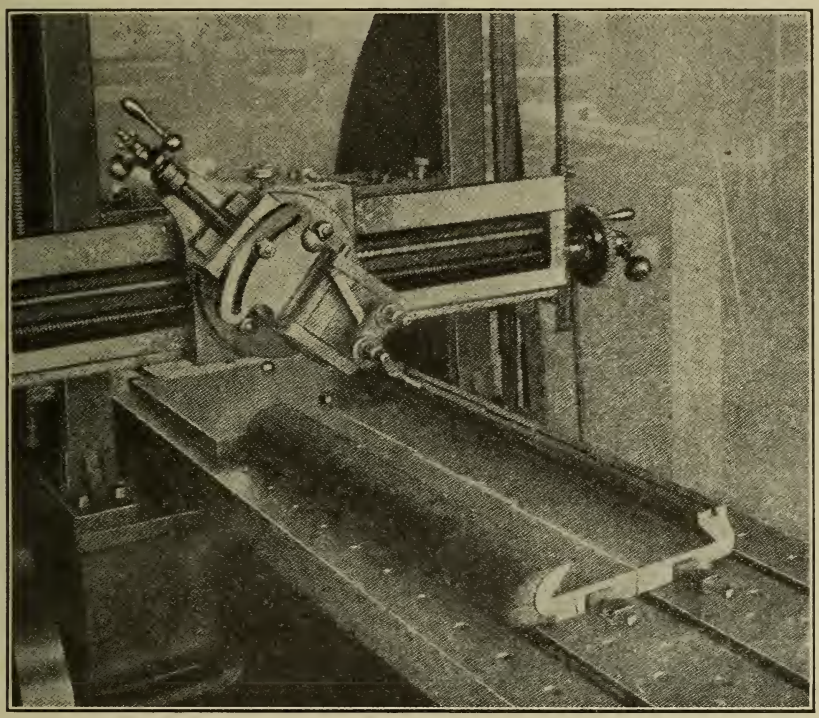


FIG. 57.—Planing taper gibs.

these saddles up against this plate and locating each one so that a sharp-pointed planer tool will pass over each of the center marks indicated by the intersection of the small cross lines and the center line, we know that they are all swung in the right position and are then clamped ready for planing to receive the taper gibs. The amount of offset can easily be seen both by the center line and by the small T-slot at the back.

Still another job is shown in Fig. 58. Here eleven milling machine knees are being planed for the column bearing, the side head being used to plane

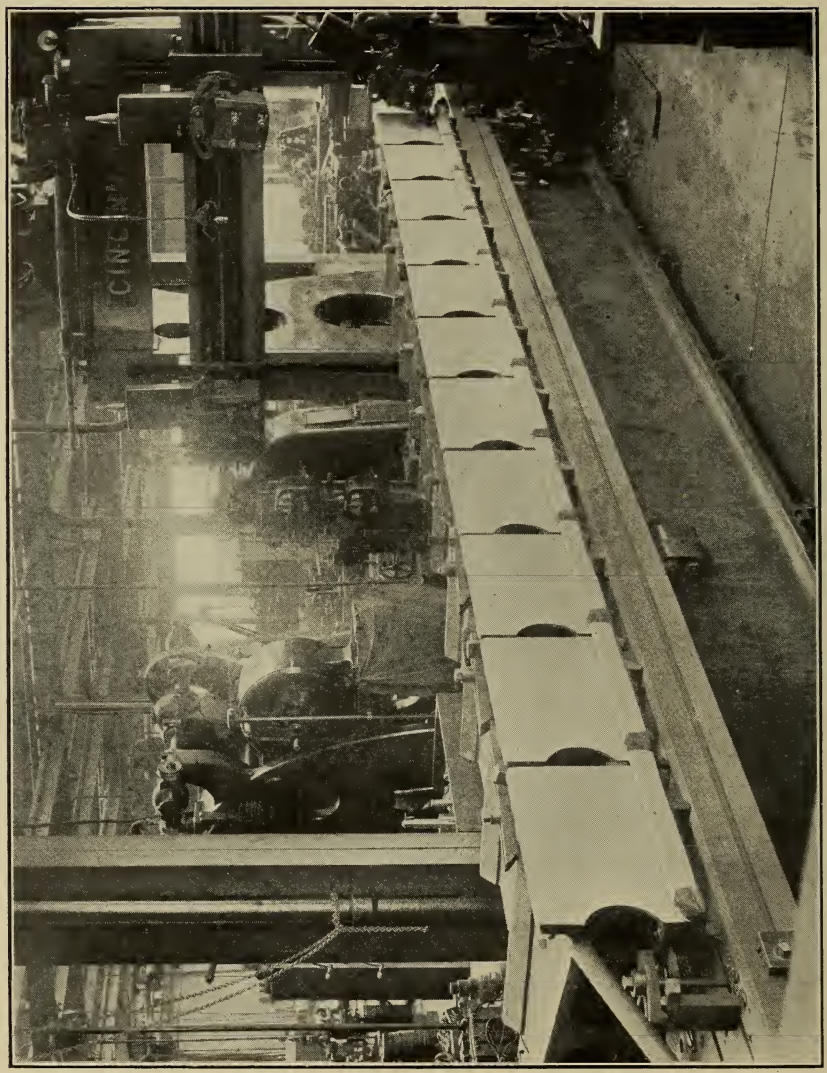


FIG. 58.—A long string of miller knees.

the flat surface and to cut the dovetail gib bearing at the proper angle. There is nothing unusual in the method of clamping. By using side head as shown the work need not be set up high off the table.

Another interesting job is shown in Fig. 59, where a string of friction flanges for a planer is having the dovetails planed out. The fixtures are independent blocks having a key which fits the slot in the planer table and central with this, on the upper side, a recess to receive and locate the hub or

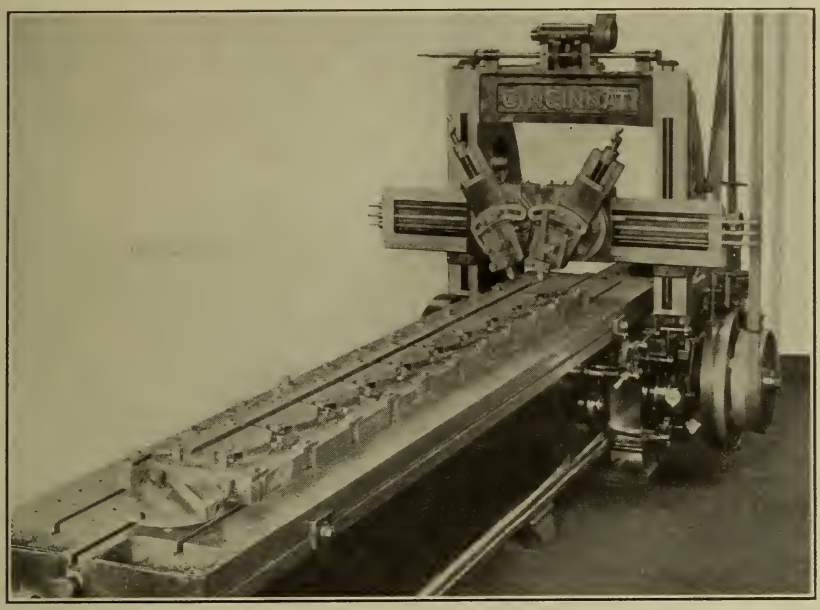


Fig. 59.—Planing a string of friction flanges.

the friction flanges. By having these blocks separate they are easy to handle and any desired number can be used according to the size of the lot going through the shop.

The friction flanges are simply placed in the blocks, centered by the small adjusting screws shown.

The heads are set to the proper angle and left in this position until the entire lot is finished, insuring everyone being exactly alike.

Planing an Index Head

The planing of an index head for the ordinary milling machine presents several interesting features and the various operations will be followed as they occur.

The first operation on this head is the planing of the bottom surface with its tongue in the exact center, as this is used in locating the head on the milling machine and also future operations. This is planed in the usual way and the

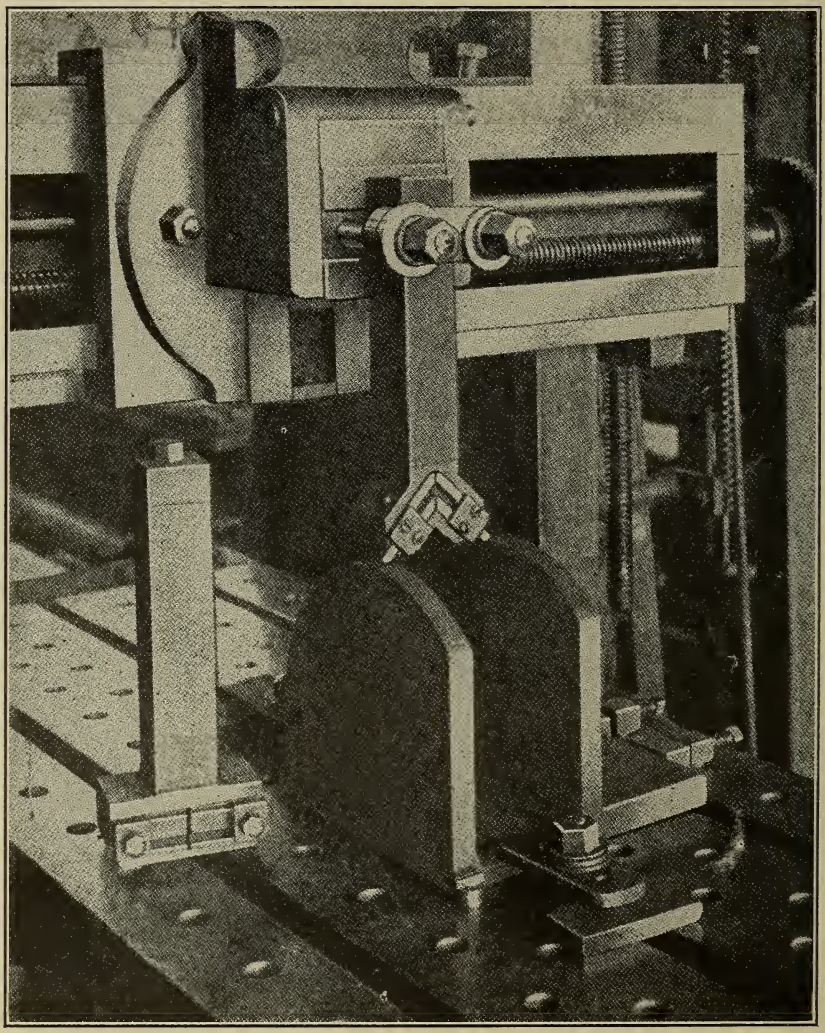


Fig. 60.—Planing with a double tool.

correct width of the tongue is determined by the adjustable straddle tool shown in foreground of Fig. 61.

The casting is next clamped to the table, as shown in Fig. 60, and the

double tool holder is used to plane down both sides at once and to secure the correct distance apart for the side pieces which can perhaps be called wings.

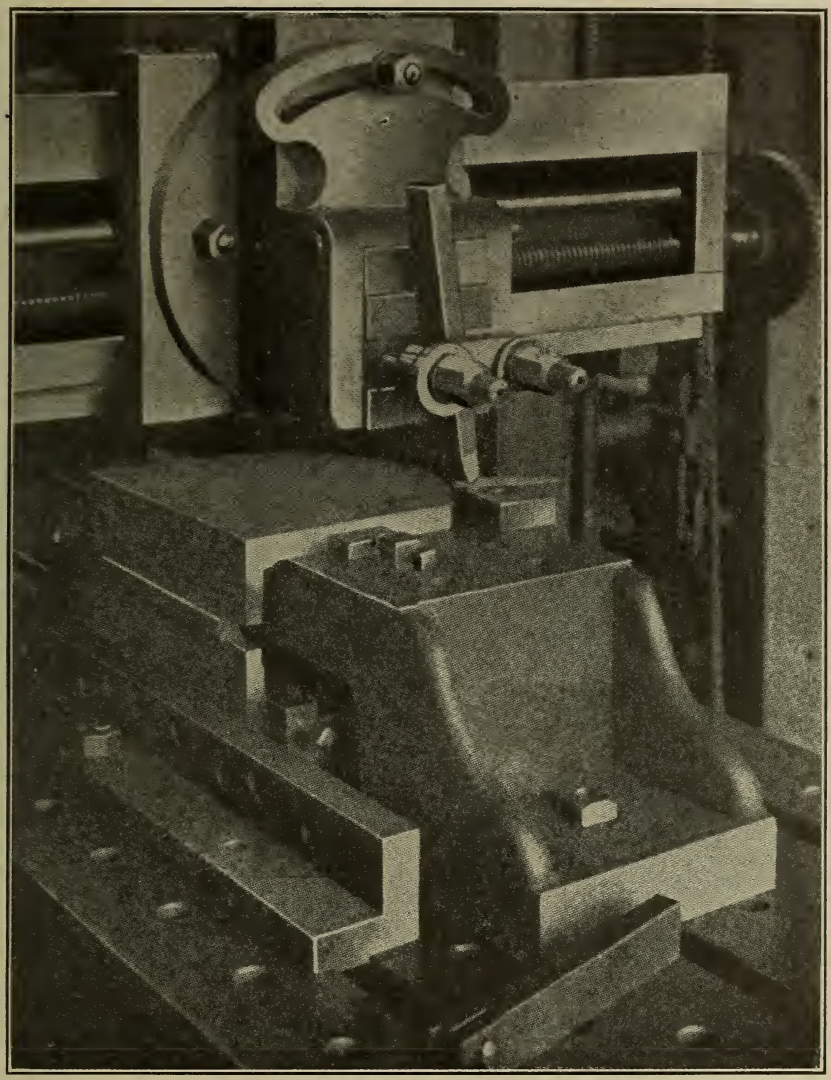


FIG. 61.—Using a bridge fixture.

These are located in line with the planer by the blocking shown at the right, and which in the case of planing a string of these would extend the whole length of the planer table.

These double tools are rather interesting, as they consist of a tool holder with two independent clapper blocks for holding the tools and for allowing them to be relieved from the cut on the backward stroke. These are very complete little holders, allowing independent adjustment of each tool and having all the advantages of regular planer tools.

The next operation is planing the sides which would be troublesome, and require either blocking or jacking in between in order to overcome the spring due to the cut if it were not for the fixture shown in Fig. 61. This can, perhaps, be called a bridge, as it allows one of the sides to go underneath while the other is being planed the same as though it was a pefectly flat piece on the planer bed. The work is squared up by the angle plate shown in front and which fits into one of the planer table slots. The blocking and clamping is plainly shown and require no description. The tool is being set for the finishing cut to the distance block shown, which is the desired thickness of the side, and the method of using tissue paper in tool setting in order to be sure that the tool is not down on the distance block, shown in the view.

Fitting the Block

Planing the block which is to fit this head is a very nice job when it is considered that the hole through the block for the indexing spindle must be exactly central with it. In order to accomplish this the hole is bored first and the mandrel, shown in Fig. 62, is then put in this hole and the mandrel supported on the blocks shown. On the front of the mandrel is the measuring block shown, which is clamped to it by the clamping screw at the back, and which carries two hardened steel measuring rods, one of which is shown directly under the tool. These rods are of exactly the same length and the inner ends are conical so as to afford a proper bearing for the cone point set-screw, which is shown between the two square heads clamping set-screws on the front of the block. This cone-point screw adjusts both of these steel measuring rods an equal amount so as to measure exactly the same each side of the mandrel on which this whole block is mounted.

These are set to the desired length so as to fit the inside of the housing into which they are to go. This measuring block is then squared up with the table so that the measuring rods are exactly perpendicular to it, the mandrel clamped solidly to the V-blocks while the block to be planed is supported underneath by strips or wedges to prevent turning. The first side of the block is then planed until it is nearly down to the desired point, and the final setting of the tool is done against the steel measuring rod by the aid of tissue paper, as shown.

Then the mandrel is loosened, the whole thing turned one-half a revolution

until the measuring rods are again perpendicular, and they are ready for the other side. This measuring block can be located in its second position in a number of different ways. By using a square for determining the position of the measuring rod, or after it has been squared up for the first side, a distance block, or an inside micrometer can be used between the table and the lower

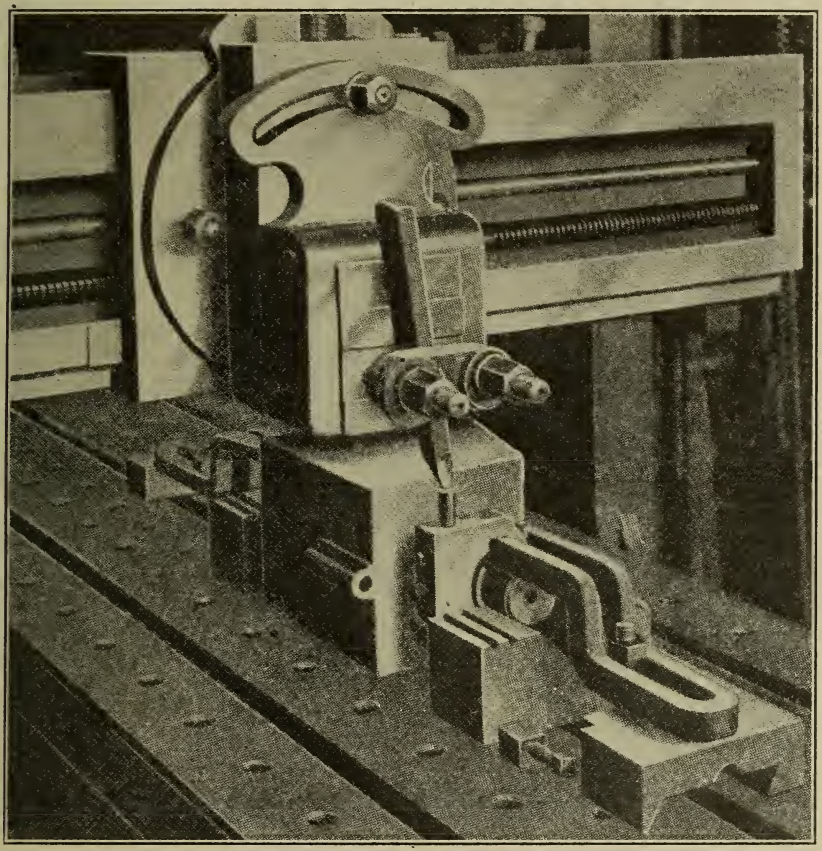


FIG. 62.—Using the gage block.

measuring rod, so that when the work is turned over, this distance between the measuring rod and the table will insure its being exactly parallel, provided, of course, the first setting was correctly done.

Another similar planing fixture is used for planing the sides of the tail-block holders, and is shown in Fig. 63. The tail-blocks go through about the same process as the index head, but this fixture allows six of them to be strung

on at one setting and materially reduces the total planing time. As the sides of these are comparatively low and there is considerable weight in the base, there is a decided tendency for them to tip while being set, and to avoid delay

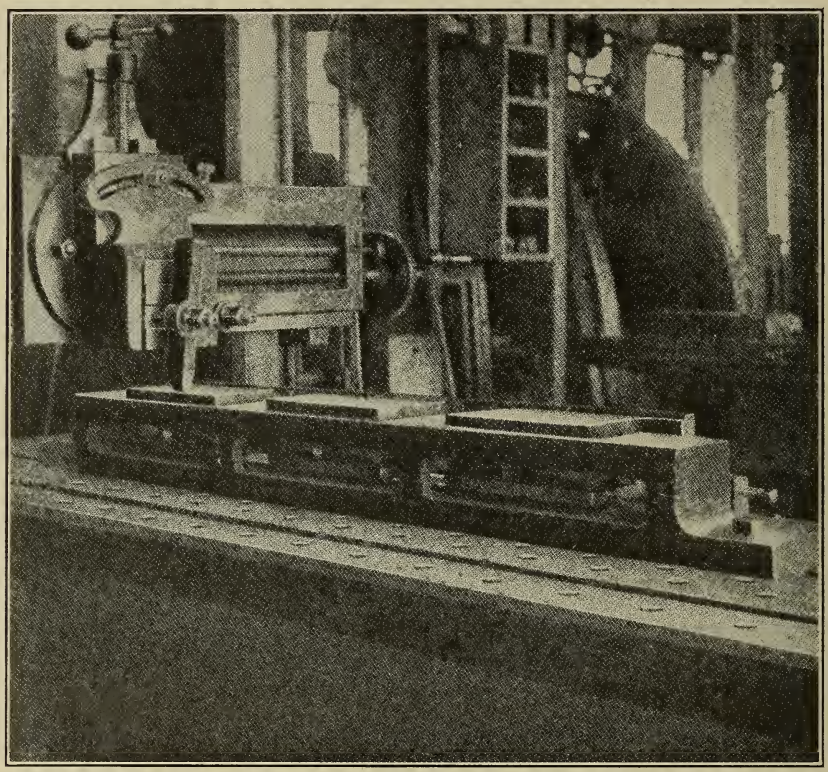


Fig. 63.—Planing the sides.

from this purpose the fixture is provided with set-screws on the under side which are screwed down until the heads bear on the inside of the piece and prevent their tipping.

Large Planing Fixtures

An excellent example of large jig planing is shown in Fig. 64. Here six large milling machine knees are strung on the planer table at one setting and both of the heads brought into operation. These are large pieces, each of the fixtures shown being about 30 inches high.

The top faces of these knees are first planed with their proper dovetail, and

the fixtures are made so as to clamp them on this surface. The fixtures are first carefully lined up with the bed so as to be perfectly square in both directions, and after this it is an easy matter to swing the castings into place and slide them down into the fixtures by means of the overhead crane which serves this planer. By substituting different widths of shoes at the sides, these fixtures can be used for several sizes, the shorter knees being blocked up from beneath so as to bring the surfaces to be planed up above the top of the fixture.

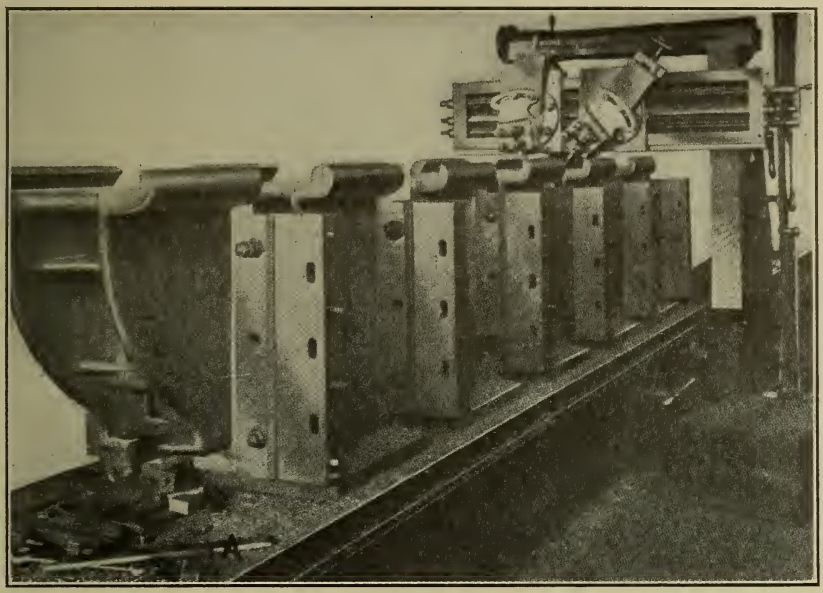


FIG. 64.—String of large planing fixtures.

It will be noticed that one side of the bearing being planed is the regular 45-degree dovetail, while the opposite side is about 5 degrees in the other direction. This allows for the clamping gib to be drawn down against the other side of the dovetail on the column of the machine, and makes a very rigid connection between the knee and the column.

PLANING LATHE CARRIAGES

Some interesting methods and tools employed in lathe building are shown in Figs. 65 to 67, and show modern practice in the use of gages and methods of testing the accuracy of work.

After the castings for the bed are well seasoned they are roughed off on the

bottom, turned over and roughed off on the top, the clamps loosened up so as to allow strains to adjust themselves and then re-clamped and the finishing cuts taken. This includes the ways or V's, the rack seat, and the inner bearing surfaces used on this lathe. This requires two cuts, the last cut being very light.

Some of the gaging fixtures are shown in Fig. 65, resting on the shears or ways. The gage *A* is a half templet of cast iron the same as shown in Fig. 69, which is reversed to test the corresponding angles of the front and back ways and shows any variation from the correct center distance at a glance.

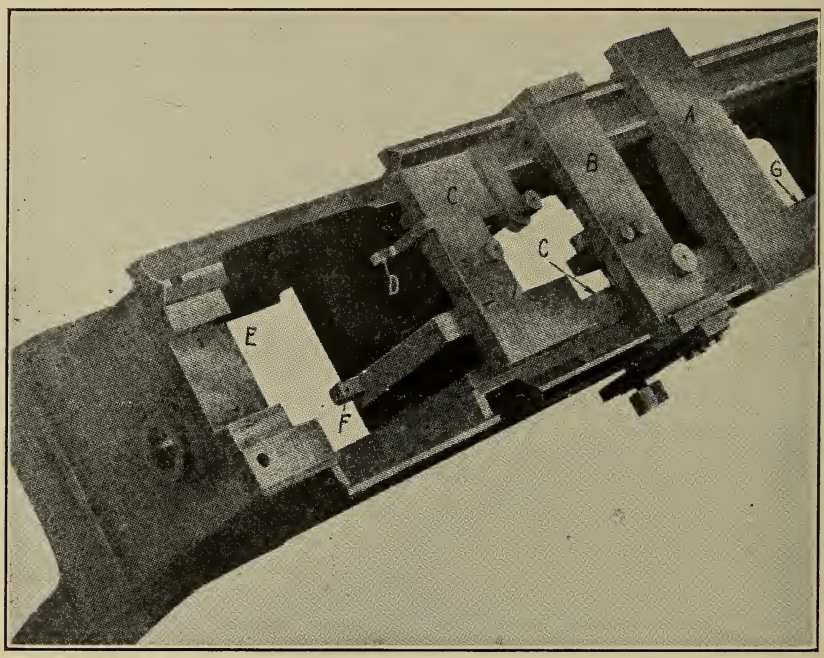


Fig. 65.—Gages for testing planing of lathe beds.

The gaging fixture *B* has a series of nurled head screws which test the planing of the flat way at the front, the seat for the lead screw bearing, and the straight inner bearing surface *G* which helps guide the carriage saddle in these lathes.

In testing these surfaces by means of the nurled head screws in *B*, a paper feeler about 0.002 inch thick is placed under the flat end of the screw and the screw run down till the head is in contact with the fixture. If the planed surface is correct within the required limits, the paper feeler is pinched between the end of the screw and the planed surface, yet may be withdrawn readily

with the fingers, showing that there is a very slight clearance between the screw and the bearing surface being tested.

This same fixture has a piece of hardened steel which projects under the front of the bed and acts as a gage for the rack seat.

Gage *C* has two screws for testing the vertical position of certain seats under the head as well as several setting points by which the planer tools are adjusted to cut to their proper depth and to finish the sides of the seats at the head end of the bed. The gage point *D* gives a setting of the tool for finishing the seat *E* for the bearing under the head for the sliding tumbler shaft. Point *F* locates the tool for planing off a bearing surface for a box carrying the inner end of the change gear shaft and corresponding in position to the hole in the outer end of the bed forming the outer bearing. A square-nosed tool may also be set at the side of gage *F* for correctly locating a groove to receive the tongue under the inner bearing just referred to.

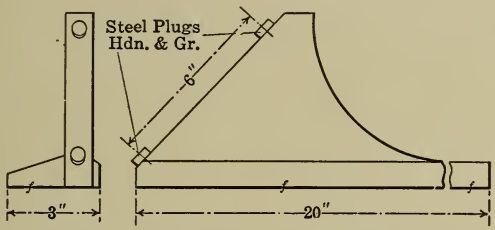


FIG. 66.—Angle gage for setting planer head.

A convenient gage for adjusting the planer head to finish the V's to the exact angle is shown in Fig. 66. This is simply a casting about 20 inches long, having at one end a vertical projection with a sloping face and in this are two hardened steel plugs which are accurately ground and lapped to the exact angle required for the sides of the V. These plugs are about 6 inches between centers and this forms a master angle which is so much larger than the V to be planed than it is an easy matter to adjust the head correctly by setting the tool to the faces of the two plugs. The bottom and right-hand side of the gage is planed and scraped in locating it on the bed to be finished, it is simply placed across the ways and swung around to right angles by bringing the side against a square.

This gage is used on all the planers for setting the heads for planing the ways of beds, saddles, head or foot stocks. It is a great help in planing surfaces to correct angles in fast time and reduces the work of the scrapers to a very low point.

Reference has already been made to the bearing surfaces under the carriage. When these have been finished on the planer they are tested by the devices and

methods shown in Fig. 67. The V's are planed the right distance apart in the same manner as the V's of the bed itself. The flat way *B*, in the front and the bearing surface *G*, Fig. 65, must be correctly located in reference to the V's, and these are tested as shown in Fig. 67. The gage *G* is a round plug which is dropped into the front V in the saddle, while the wing across the plug should just make contact with the piece of tissue paper resting against the vertical bearing surface indicated. The outer end of the arm fixed across the plug also serves as a setting gage for the square-nosed tool used for planing the

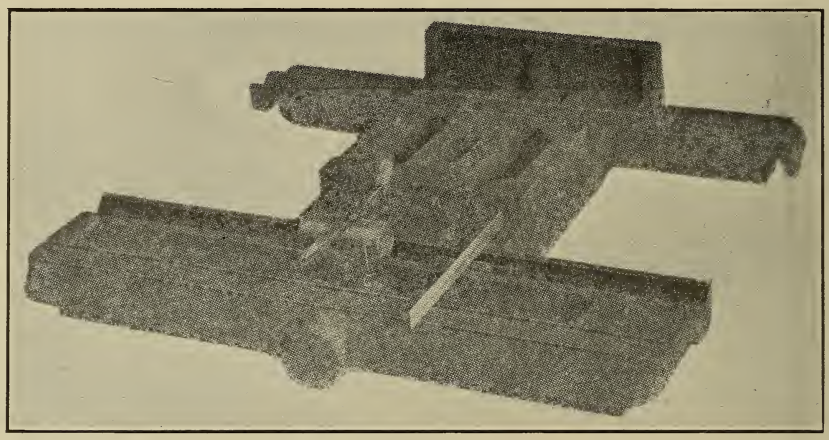


FIG. 67.—Testing carriage bearing surfaces.

groove under the carriage to receive a locating tongue on the top of the apron.

The flat surface *B*, Fig. 67, is tested in relation to its V by placing the plug *H* in the V and resting a scale or straight edge on this plug and on the flat surface. The plug is ground to an exact diameter so that its top shall be exactly even with the plane of surface *B* and any in accuracy here is easily detected by the rocking of the straight edge used in the test.

USING PLANING GAGES

The use of master or planing gages is very clearly shown in Fig. 68, and those who are not familiar with this way of planing to the correct size will find it both interesting and instructive. It does away with all but the preliminary laying out, which is, of course, necessary with the first surface planed in order to have the castings clean up along its entire length. But after the first surface has

been correctly planed these gages provide a quick means of getting very accurate results and practically cut out all chance of making mistakes.

In this case the inside or column dovetails have been planed first, and the knee is simply slipped down over a form or angle plate *A*, which represents the column of the milling machine itself. In setting this angle plate it is, of course, necessary that great care should be taken to have it squared with the planer table in both directions, but after this is done no further attention need be paid to this end of the work, and the knees to be planed are clamped to this plate and supported at the outer end in any way that will prevent springing under the cut.

The gage *B*, shown in place has a dovetail projection at the back which just fits inside the planed surfaces of this bearing of the knee, and has been carefully laid out so that the angular sides shown in front are in exact relation

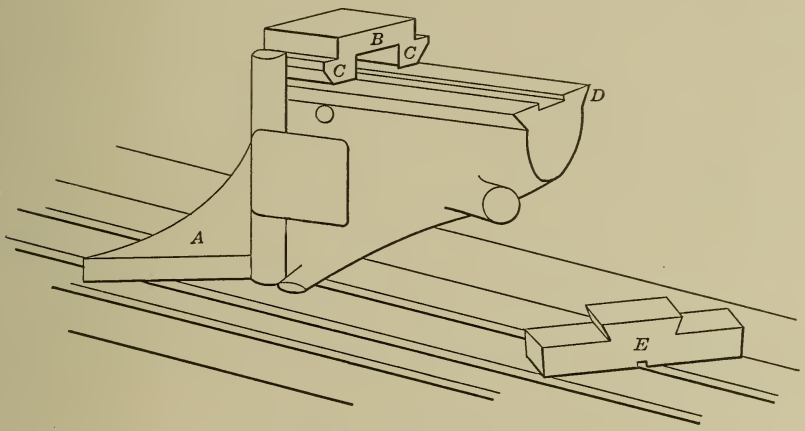


FIG. 68.—Using planing gages.

to the dovetail projection which are slid into the fixture. This gage is put in place after the top surface of the knee has been planed, and all that is necessary is to set the planer head at the desired angle, 45 degrees in this case, and plane the angular sides until these sides are a continuation of the angular sides *C C* of the gage. When this is accomplished on both sides of the knee, the planer hand knows without measuring that they are correct and will fit the table which is to be mounted on them.

The other gage *E*, shown lying on the planer table, is used in a somewhat similar way, being located in front of one or more carriage slides, and the dovetails planed until they match the dovetails of the gage. Both the work and the gage are located by a steel strip which fits the planer table slot and also the slot in the work and in the gage.

Gages for Machine V's or Ways

The form of gage shown in Fig. 69 has become very popular for planing the ways of lathes, planers and other machinery. Instead of the gage with a full V at each end, which prevents your knowing just exactly where you are until it actually fits, the single sided gage shown, gives the correct angles as shown in Fig. 70.

Fig. 69.—Gage for planing ways or V.

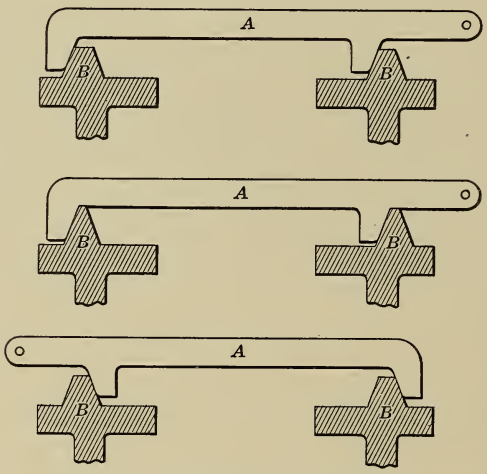


Fig. 70.—Half gages for planing V's.

Fig. 71.—Gage with micrometer screw for locating the rack seat.

This shows a sheet metal gage used for both sides of the V and indicates how the center line remains the same with both the thick and thin V.

The halfway V gage always insures getting both V's the same height and width as well as the exact centers.

The other gage, Fig. 71, is for locating the height of the rack seat on a planer table. After the V's are planed, the gage is dropped in place and the rack seat located with reference to the V's by the micrometer screw shown. This has a graduated thimble and can be read to thousandths of an inch.

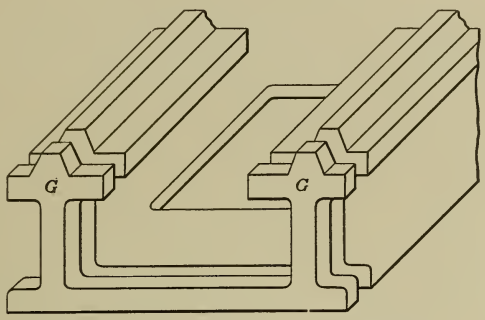


FIG. 72.—Planing gage for small lathe bed.

This same type of gage will be found useful in other cases where the proper location of a third or fourth part depends on the height of the first two.

Fig. 72 gives in outline, a gage *G*, made for setting tools and for planing a lathe bed to size. This is along the line of the gages previously shown.

MORE FIXTURES AND GAGES FOR LATHE WORK

The methods shown in Figs. 73 to 76 illustrate a few more special tools and appliances utilized in the building of engine lathes. These tools include planer fixtures for holding various lathe parts, one or more at a time; gages for setting planer tools for finishing such parts and for testing the accuracy of the work after planing.

FIXTURES FOR PLANING TAILSTOCKS

The planer fixture in Fig. 74 is one of a set of twelve, placed, when in use, in a row on the planer platen for machining the lower surfaces of tailstock tops. A tailstock casting is shown to the left in the view, with an empty fixture in the center of the group, and a casting in position as it is actually held for planing, at the right.

The idea is to chuck the work so that it shall be planed in the correct relation to both ends of the rough barrel, which in a later operation is bored out to receive the tail spindle. It is desirable that the casting be located from the rough barrel ends as this will assure the hole for the spindle being bored central with the casting, making a neat appearing piece of work when viewed from either end.

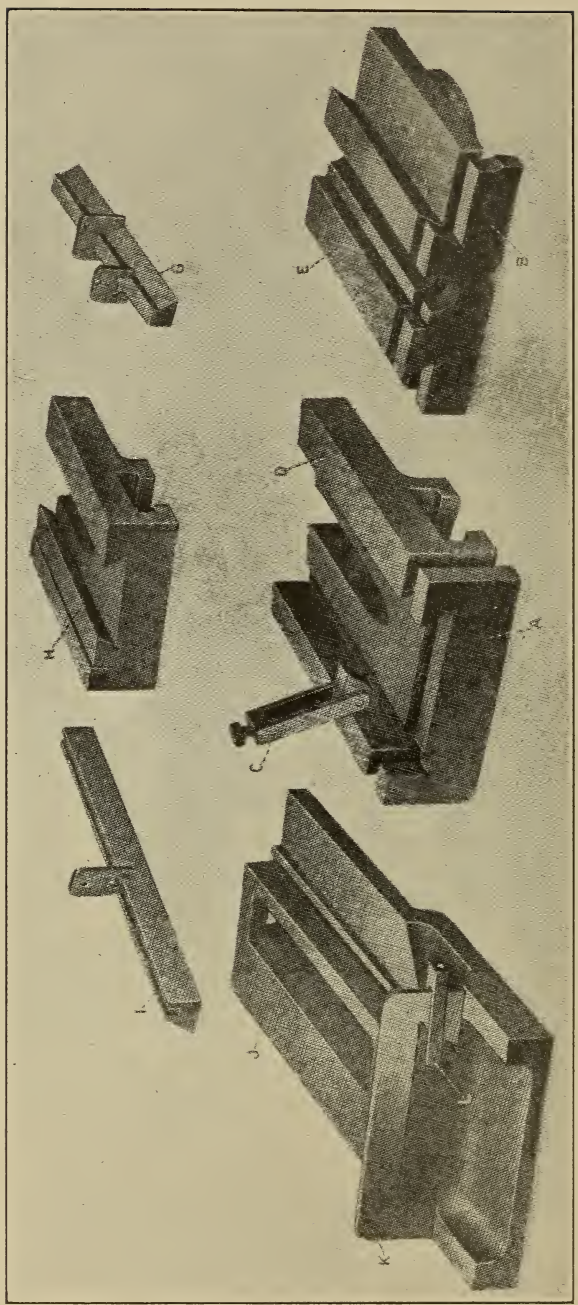


FIG. 73.—Dovetail planing gages.

The planer fixture is fitted, as indicated, with cup centers to receive and locate the tailstock casting by the ends of the barrel, the cup at one end having an end movement controlled by a set screw, to bind the work longitudinally in the fixture. There are three jack screws which are brought up under the projecting base of the casting. Two of these are located at the left side of the fixture and, when the string of fixtures are placed upon the planer, they are set crosswise with the single supporting screw in advance so that the pressure or thrust of the cut is taken upon the two screws under the opposite side of the casting.

The fixtures are located square upon the planer table by means of the tongue at the underside. After the bearing face of the tailstock has been planed and the groove planed across for the reception of the tongue on the upper surface of the bottom plate, the tailstock is scraped to its bottom plate and the hole for the spindle is then bored in a fixture which brings the hole parallel to the base, square with the crosswise tongue and central with the projecting hubs or barrel ends.

Planer Templets and Dovetail Gages

The gages in Figs. 73 and 75 are used for setting planer tools for planing the top slides, swivels and bottom slides for compound rests, and also for testing the accuracy of the planing operations. Thus in Fig. 73 a gage set consisting of members *A*, *B* and *C* is illustrated as used in connection with the planing of the

Fig. 74.—Planer fixtures for lathe tailstocks.

dovetail and gib bearing surfaces on the top slide *D* and swivel *E*. As here shown the two dovetail gages are adapted for the setting of the planer tools and in actual service are clamped to the platen at the end of a long row of castings. These gages are of steel, hardened, ground and lapped.

Considering for a moment the application of the gages or templet *A* for the top slide, the castings are first roughed down on the top surface, then turned over to the position shown. The setting gage *A* for the tool is placed on a thickness or two of paper and the bottom of the slide, the dovetail surface and

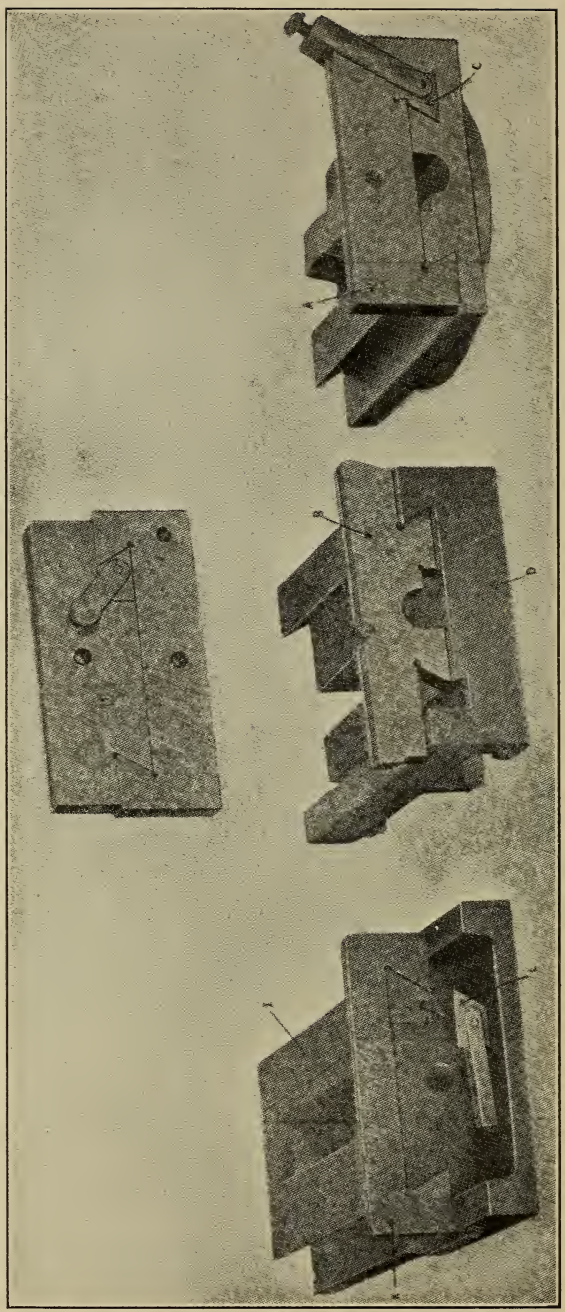


FIG. 75.—Dovetail planing gages.

the straight surface and groove for the gib are roughed down and finished, the tools being set to the hardened gage edges for the finishing cut. When the work is turned over for finishing the top surface the gage is turned and clamped directly on the platen, without the paper underneath, and this drops the gage or templet just enough so that the tool, when set to the top of the gage, will take a finishing cut over the work. The dovetail gage *B* for the swivel is made use of in similar fashion.

The Form of the Gibs

A word may be said here about the gibs for these slides. The shape of the top slide gib is well shown at *G*, Fig. 73, and a gib of this type will be seen in place at *H*, Fig. 73, and also in the end view in the drawing, Fig. 76. The gib fits nicely against the vertical wall of the top slide and in the groove in the bottom of the slide, and the adjusting screws tapped in from the top, by which it is held in place, enable it to be drawn into its seat as far as required at either end to take up thoroughly any wear that may take place.

The gib *I* for the bottom slide *J*, Figs. 73 and 75 has a tongue on the inner edge that fits into a groove formed behind the narrow tongue on the slide itself. The nature of the fit is represented in Fig. 76, which shows the clearance provided between the front of the groove in the gib and the corresponding face of the tongue on the slide. This construction allows the gib to be drawn up perfectly true and square with its screws without possibility of cramping, and, as with the top slide gib referred to, adjustment for wear is readily effected.

Gaging the Work

The gages for these gibs are shown on the work in Figs. 73 and 75. It will be noticed in the case of the bottom slide gage *K* that this gage is first used as in Fig. 73 to test the accuracy of the dovetail surface at one side and the straight surface at the opposite edge for the gib, and then the inserted section *L* is removed from the gage and the open dovetail gage applied to the slide with the gib in place, as illustrated in Fig. 75. Thus the gage with its inserted jaw answers for the slide test with and without the gib.

Returning now to the gages for the top slide and swivel, these are actually applied to the bearing surfaces in the work as indicated in Fig. 75. Here the gage *A*, which was shown in Fig. 73 as used for a planer templet for the bearing surface of the top slide, is represented in place on the dovetail guide of the swivel. The gage block *C* is carried by the main gage *A* to represent the gib while gaging this dovetail bearing, and this same auxiliary block *C* may also be attached to gage *B* for testing the full width of the bearing surface and gib seat in the top slide *D*.

The gage completely assembled is illustrated in the sketch, Fig. 76 and this shows how the removable block *C*, which represents the gib, may be attached

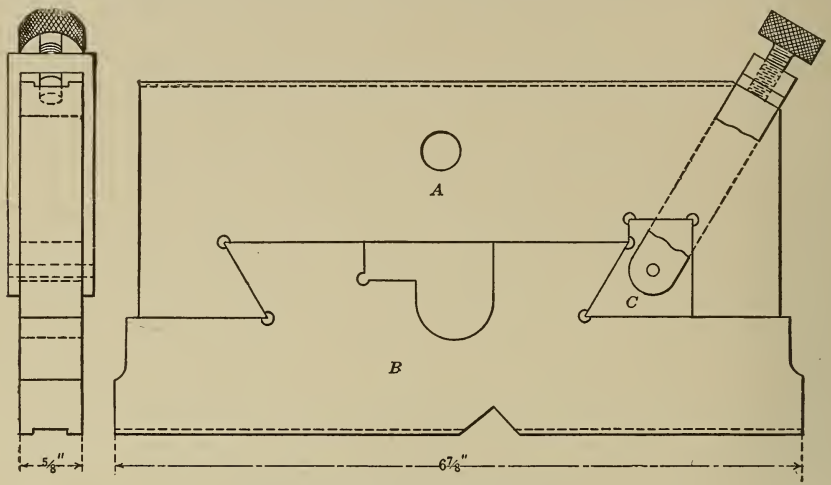


FIG. 76.—The gage assembled for use.

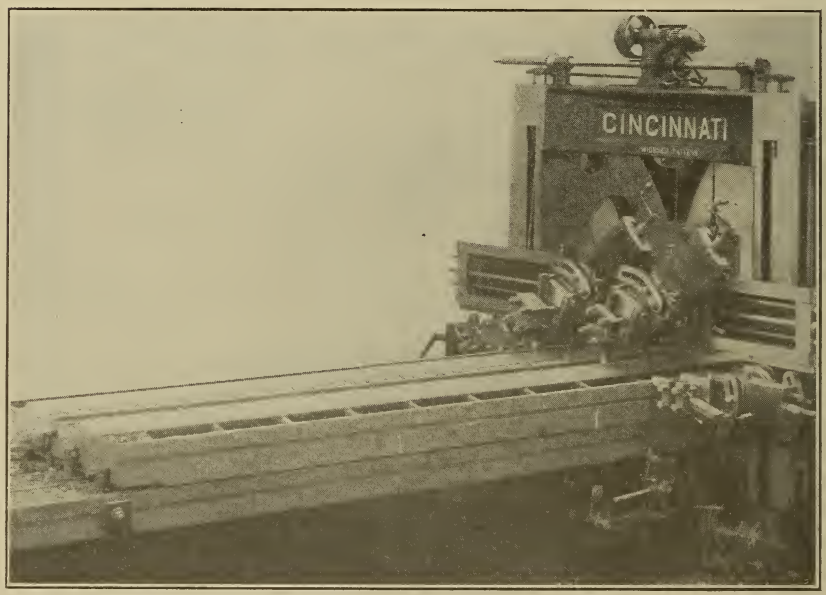


FIG. 77.—Using all four tool heads.

to either the male or female dovetail gage. In the sketch the block is connected to gage *A*, but upon releasing the thumb screw at the upper end of the link, the

latter may be swung down to allow the block *C* to be withdrawn from its seat. To attach the block to gage *B* the locking link is swung around to bring the clamp screw against the notched seat at the bottom of the gage.

These gages are finished so nicely as to fit perfectly at every point in the joint. They are relieved along the edges that rest upon the planer when used as tool-setting gages, leaving two bearing surfaces about 1/8 inch wide. Another set for a different size of lathe rest is shown at *M*, Fig. 75. The removable block in this case is drawn into place in either of the main members by a nurled-head pin which has an eccentric body fitting the hole in the gage. A slight turn of the pin draws the block up snug in its seat or releases it.

While some work hardly admits of using all four tool heads at the same time there are many cases where this means a considerable saving in time and money. A case of this kind is shown in Fig. 77 where a planer table is being planed on the under or bearing side. Both sides are being planed and the two heads on the cross rail are set to plane the far side of the V's, the near side having been finished. This shows the use of end stops and the way in which the bed is clamped down to the table.

Before this is taken off the planer the seat for the rack will be planed, using the gage shown in Fig. 71.

Planing Locomotive Cylinders

The planing of locomotive cylinders calls for considerable ability in the way of blocking up and clamping the work as well as deciding on the best methods of getting at the surfaces to be planed without too much overhang to the tools. Fig. 78 shows a pair of piston valve cylinders set up for planing the center joint as well as the surfaces which come over the frame.

The cylinders rest in the V blocks on the table while the saddle end is supported by substantial jacks or other blocking which cannot be seen. The cylinders are lined up parallel with the table by means of the fumed projections which fit into V-shaped fixture to bring all the planing parallel in order that the two cylinders may be in line when the halves are bolted together.

The cylinders are clamped down to the table by the long clamps, the holding down bolt being near the work so as to be most effective. The long angle braces take the trust of the cutting tool up near the surface being cut, which prevents the cut throwing the work out of line. These braces are anchored by the cross pieces against the two stop pins shown.

This method allows three heads to be at work and divides the work up so as to handle it rapidly.

Another form of cylinder and the way it was handled is shown in Fig. 79. This uses a side head somewhat different from usual practice, which is well

braced so as to take a good cut even with the reach shown. The two diagrams make this clear.

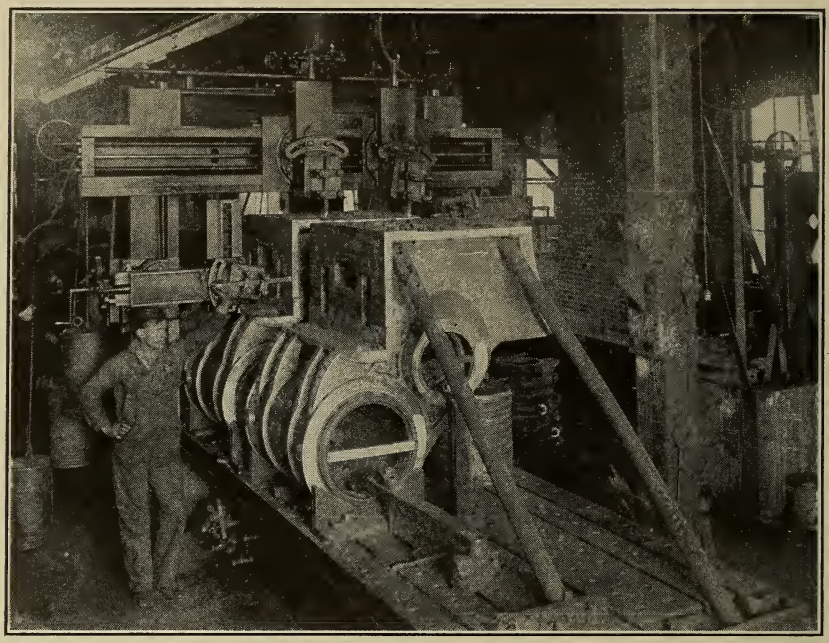


FIG. 78.—Planing a pair of locomotive cylinders.

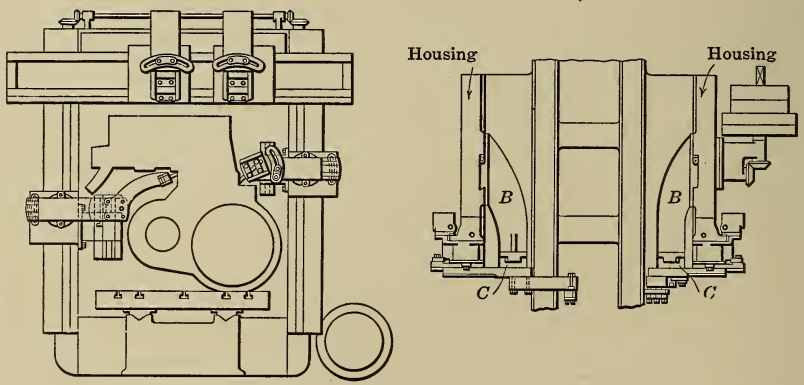


FIG. 79.—Special tool heads for locomotive cylinder work.

It is often very advantageous to cast holding pieces on work to be planed as shown in Fig. 80. This enables the work to be rigidly held and yet leaves

the surfaces to be planed perfectly clear without the work of drilling holes for finger clamps or similar devices.

A very neat method of finishing flat surfaces is shown in Fig. 81. The

FIG. 80.—Holding lugs cast on pieces to be planed.

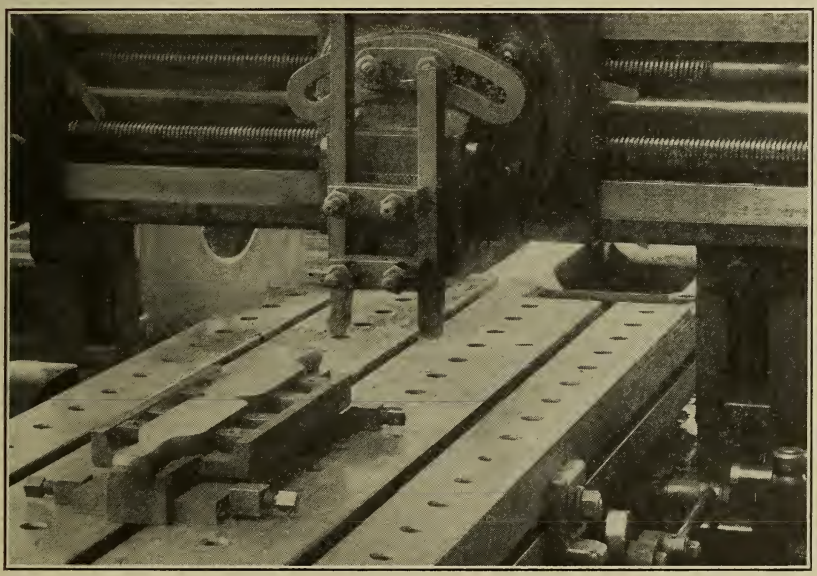


FIG. 81.—Using a roughing and finishing tool together.

fixture itself is held by the four screw stops which fit into the holes in the planer table. These bear against strips which hold the fixture in place on the table. The inside edges of the fixture are taper and taper jaws are drawn down against

the work by the screws whose heads are underneath the fixture. This holds the pieces firmly in place.

The plan of using two tools, one for roughing and the other for finishing, in the same head will be found useful in many places of this kind. The roughing tool is in position to cut and by the time this gets across the work the finishing tool is ready to begin its work. This does away with changing tools and makes a very fast method of surfacing which makes it possible to beat the milling machine on work of this kind.

Planing Crank Case Bearings

An unusual job of planing is shown in Fig. 82 in the shape of an aluminum crank case for a six cylinder automobile engine.

The top surface *B* holds the cylinders, the edge *P* being planed for a setting line or surface when it is turned over, so that the bearing for the crank shaft could be lined up with it.

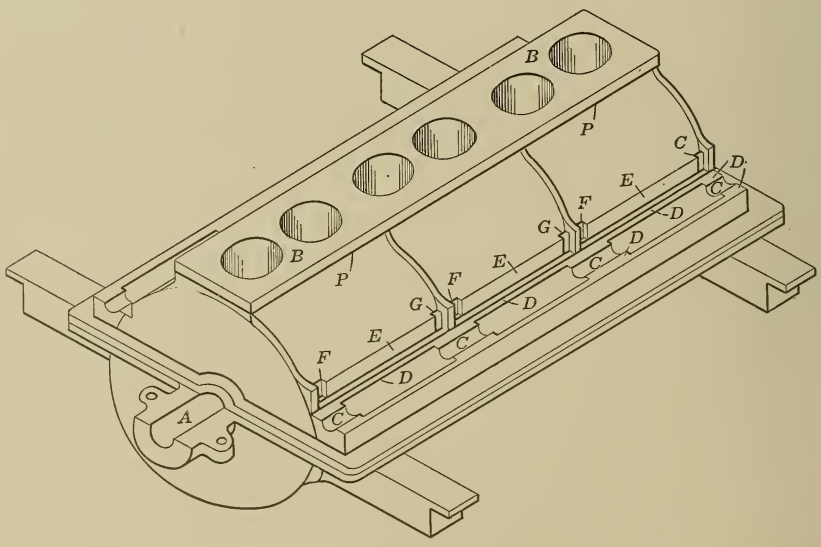


Fig. 82.—Planing a six-cylinder automobile crank case.

Surfaces *E E E* and all the *D's* had to be planed at the same setting. Before planing *E*, the recesses *F* and *G* had to be chipped for the planing tool to run into in starting and stopping as in any case of this kind.

The cam shaft runs in the bearings *C C C C*, and instead of boring these with a bar, which would have to be very long and slim, they were planed at

the same setting by using a tool with a half round nose of the right size. The seats for the cam shaft on the other side were planed in the same way and a good bearing secured in this way.

The lower half of the crank case was planed in the usual way and the bearings also cut with half round planer tools. In addition to the outer bearings *A*, at the ends, there are two internal bearings in line with the ribs on the outside of the case. These were planed to receive bronze boxes, as the shaft did not bear directly on the aluminum.

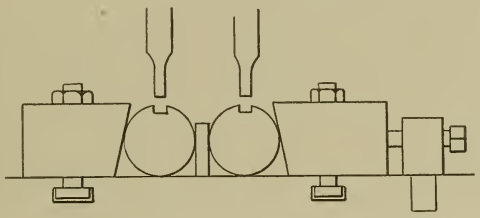


FIG. 83.—Method of holding round shafting.

The caps were also planed in the same way but none of the bolt holes drilled until all planing was done. Then a steel shaft was placed in the bearing, the cap put in place and both drilled while held firmly in line, reversing the usual method of doing a job of this kind.

There are doubtless many places where a similar plan will save time and money as in this case, saving the cost of boring bars and doing the work in good time.

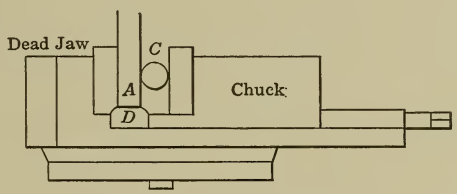


FIG. 84.—Holding work in chuck.

Fig. 83 shows a method of holding round shafting or bars for splining and of preventing them from lifting under the cut. A single one can be cut in the same way. This same method can be used for holding round work for any other purpose and may be used more for round ends on other work. V blocks are also used and the shafting clamped down into them.

Fig. 84 shows a round rod *C* used in a chuck between the jaw and the work *A*, to prevent the work being raised in tightening the chuck jaw.

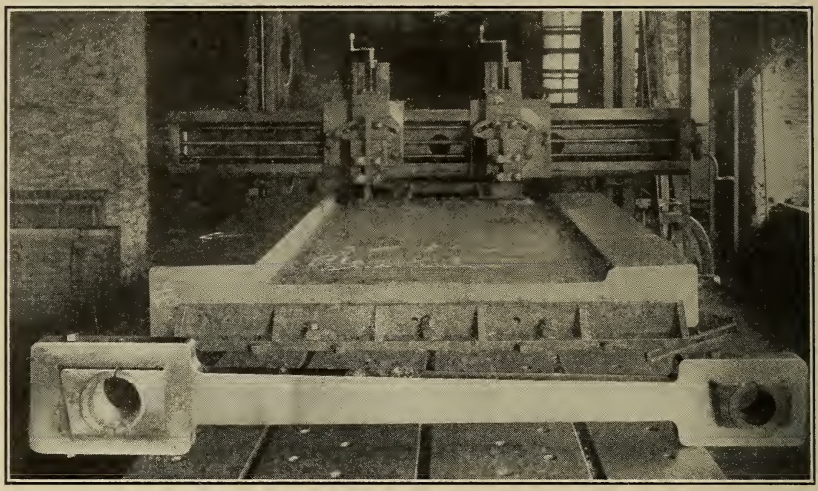


FIG. 85.—Planing connecting rods.

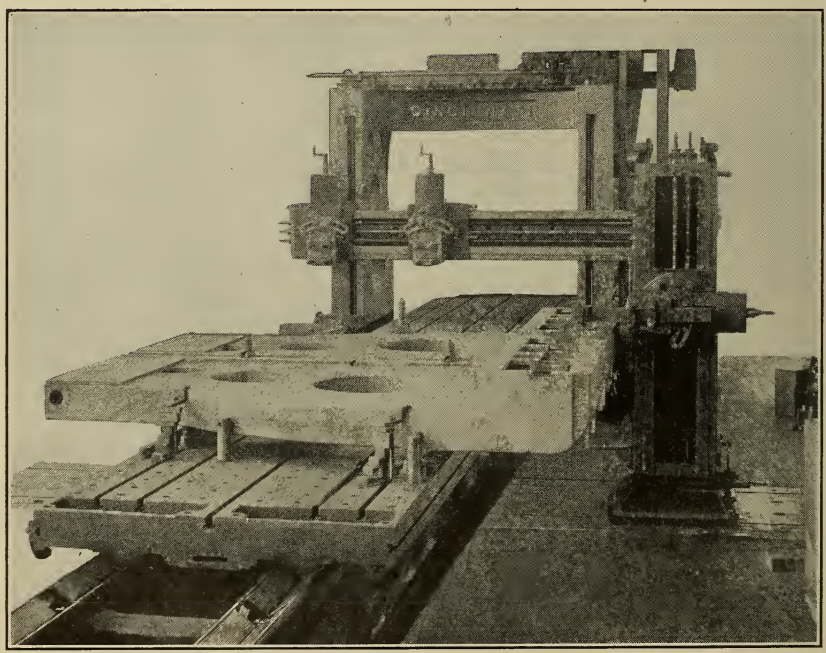


FIG. 86.—Using a Cincinnati floor head.

Planing Connecting Rods

A good manufacturing job is shown in Fig. 85 where connecting rods for steam engines are being planed in quantities. These are made from the flat bars, the sides being planed first and then a string of them set on edge, while the rod is shaped as shown. They are 5 1/2 feet long, 9 1/2 inches deep and are planed complete in five hours.

The Use of a Floor Head

It occasionally happens that a casting must be planed in such a way that will not permit its passing through the housings; for work of this kind the floor head will be found to be very handy. Fig. 86 shows this head at work planing a slot into a pair of housings; this head can also be used on the left side thereby making it possible to plane a job much wider than the rated size of the planer. This head is usually provided with power feeds and makes a very handy arrangement.

An Emergency Job

This is one of the many emergency jobs of planing that have to be done and that tax a man's ingenuity to the utmost. This is especially true of a job shop that gets the reputation of never letting a job go by.

An Extension Tool

It sometimes happens that it is necessary to plane a piece of work that is too wide to go between the housings. In such cases men often rig up extension tools which will reach across the work before it touches the housings. These are always unsatisfactory on account of the spring and an extension head as shown in Fig. 87 is much better in every way. This head is fastened to the saddle in place of the regular swivel and has an eye for easy handling with the crane. It has a complete head on its outer end and is very satisfactory for this kind of work when not over 3 feet wide.

A Convenient Spiral Planing Device

There are many different methods of cutting spiral slots on a planer and the one illustrated in Fig. 88 has been in use many years in the shops of Curtis & Marble, Worcester, Mass.

As will be seen the roll *R* to be planed is mounted in the blocks and held by straps just so that it can be turned easily by the gearing shown. The casting *A* is bolted to the planer table and carries the drum *B* which turns the work to be planed, through the bevel and spur gearing shown. The drum is revolved

by a chain wrapping around its periphery, one end of the chain being fastened to a support at the end of the planer, the drum being returned to its original

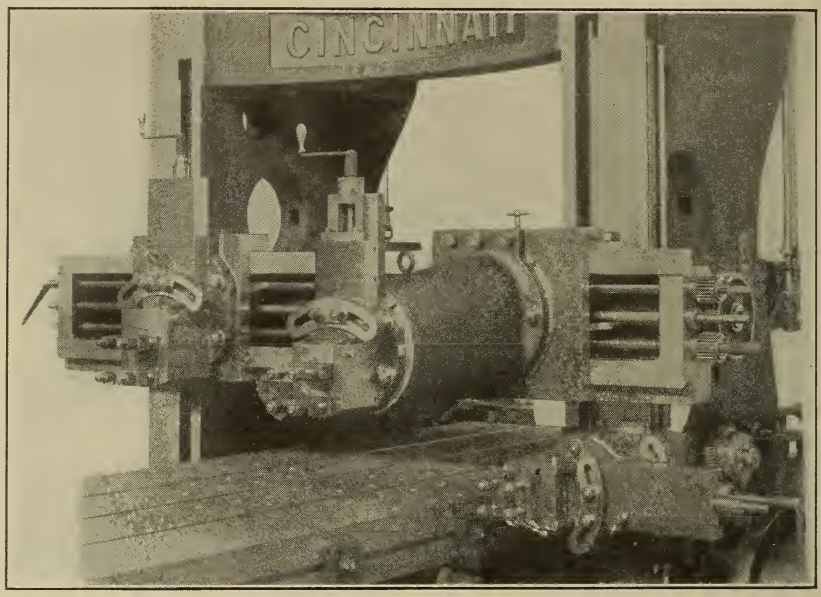


Fig. 87.—Extension head for planing work wider than housing.

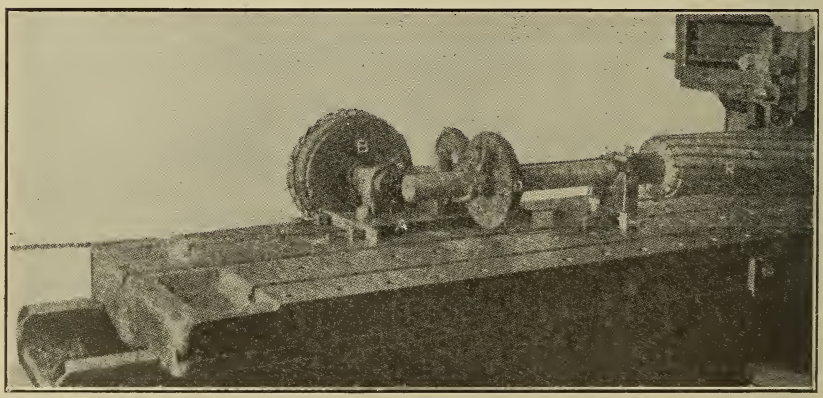


Fig. 88.—Spiral planing device.

position by a chain running to the opposite end and being hidden by the planer table.

It will readily be seen that as the planer table moves under the cross rail the

drum is revolved by the chain at the left and the work is turned according to the number of teeth in the spur gears. These gears can be changed so as to secure any reasonable degree of angle of spiral which makes this device more universal than is generally the case. It will also be noted that the gear *D*, on the shaft carrying the work, has a number of index holes and that an index pin is so located that the work can be turned any part of a revolution so as to have the desired number of slots located in their correct position around the periphery. There are probably many places where a similar device could be used to advantage.

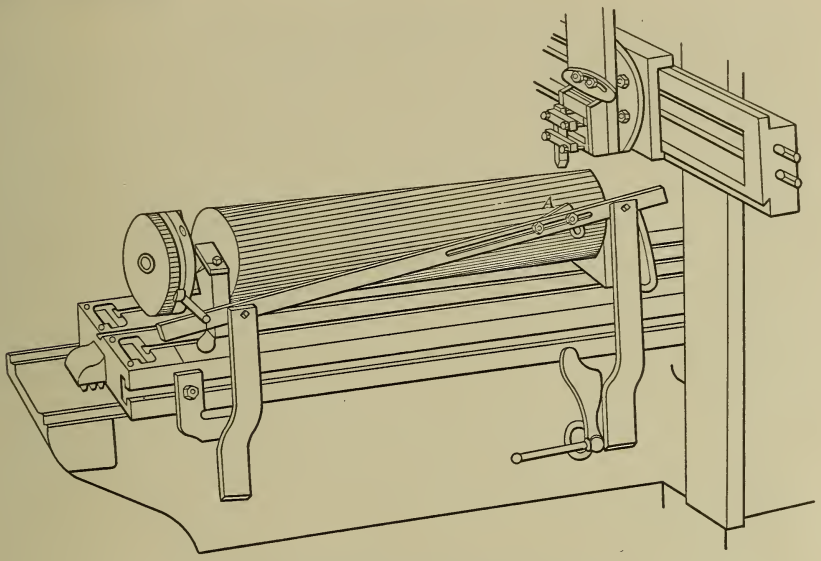


FIG. 89.—Another spiral planing device.

Another device for accomplishing the same purpose is shown in Fig. 89. Here the rotary movement of the work under the tool is given by the stud which is attached to the work and which slides in the slot in the inclined bar. The angle at which this slotted bar is set, determines the amount of movement of the work and the spiral of the groove which will be cut.

RADIUS PLANER ATTACHMENT

The radius attachment shown in Fig. 90, and known as the Allner-Boswell radius attachment,is a recent product of H. B. Underwood & Co., Philadelphia, Penn.

In it a square block which is integral with the bottom plate, that is fixed to the planer table, transmits the driving power to the top plate always in the

direction of the reciprocating movement without giving a resulting force with the tool resistance, other than parallel to it. The oscillating component of the mechanism is produced by an enlarged pin that surrounds the square block kept down by a cover plate. An enlarged eye engages around the pin and with a retaining ring forms on its top side the setting table. For setting up, the link is lined up to a center line marked on the chuck.

Owing to the very small amount of stress the radial bar is a tube and being comparatively light is easily handled. It permits of adjustment to radii of

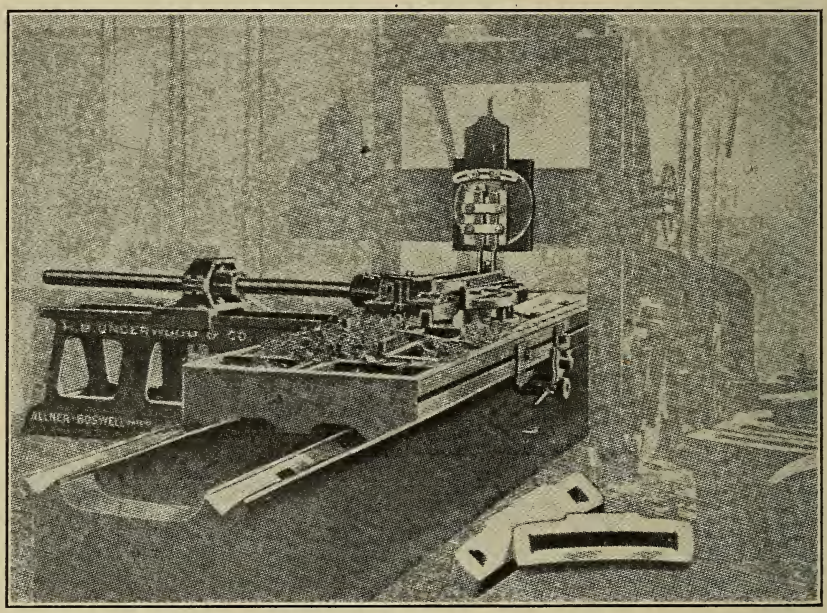


Fig. 90.—Allner–Boswell radius planing attachment.

different lengths by means of a guide that is double-pivoted in a post sliding on a foot plate perpendicular to the planer direction. This radius attachment allows very strong cuts and stands up to the limit of the machine tool without injury. After the link has been planed, milled around the edges, the end clearances drilled and slotted, it is set up on the chuck table and the center block removed by parting with two tools simultaneously. This parting operation, including setting-up link and lifting-out block after parting has been done on a 15-horsepower planer in 35 minutes, the link of hammered steel 3 1/2 inches deep. The attachment can be used not only on links, but also on dies, quadrants, etc.

Planing Convex and Concave Arcs

Fig. 91 shows a fixture for planing convex arcs. The length of the link *a* corresponds with the radius of the arc to be planed; it swings freely around the bolt *b* in the bearing *e*, which is bolted to the crossrail of the planer. The tool

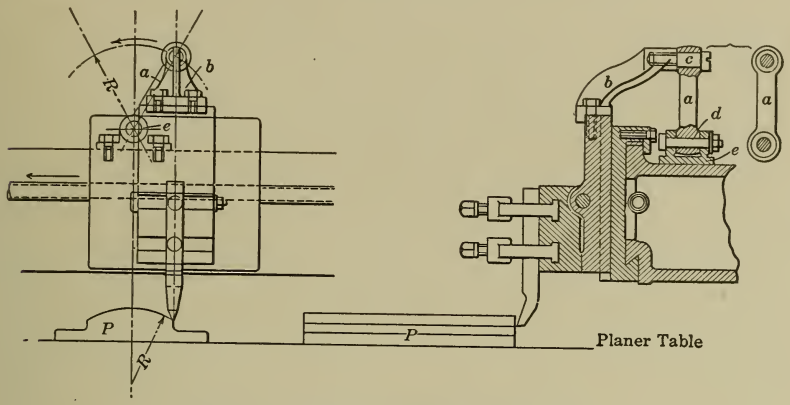


Fig. 91.—Fixture for planing convex arcs.

box is allowed to run freely and is connected by the casting *b* with the free end of the link *a*.

In operation the saddle is traversed across the rail as usual, forcing the link *a* to swing around the bolt *d* and causing the tool box to rise or fall corre-

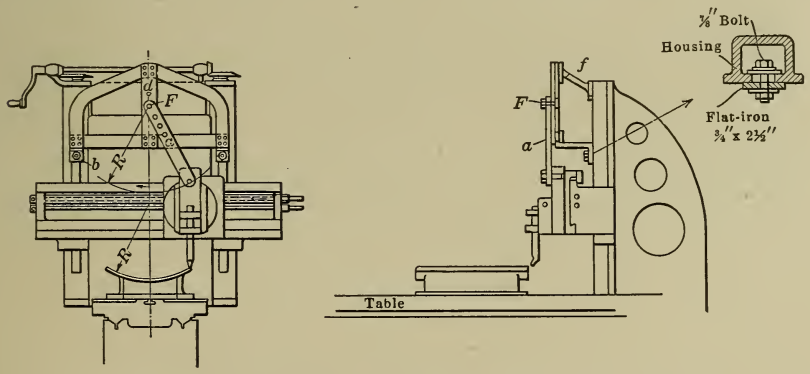


Fig. 92.—Fixture for planing concave arcs.

sponding to the position of link *a*. To plane any desired radius it is only necessary to change the length of the link *a*.

Fig. 92 shows a fixture for planing concave arcs. The idea is the same as in the foregoing one. The length of the link *a* corresponds with the radius of the

arc to be planed. The tool box is allowed to run freely and is directly connected with the link *a*. How the fulcrum *F* for the link *a* is obtained may be easily seen. The whole fixture is built from flat iron 3/4×2 1/2 inches and is especially designed for large-sized work. The section shows the connection between fixture and housing of the planer.

Another concave attachment is shown in Fig. 93, together with the work it does lying on the floor beside the planer. These are short pieces of mangle

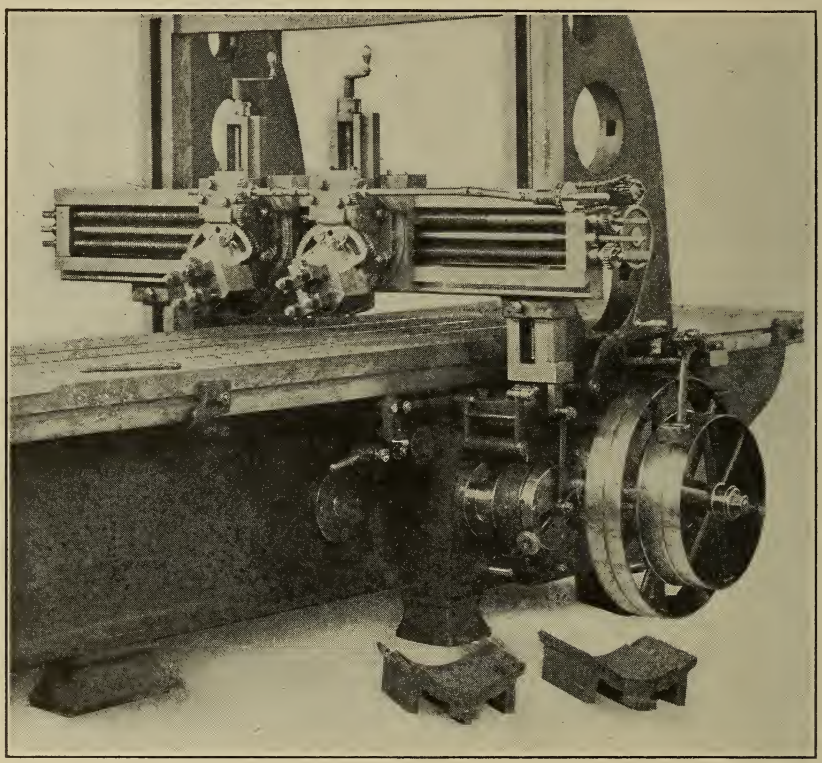


Fig. 93.—Another concave attachment.

chests used in laundry machinery. In this case the tool block has a worm cut on the arc at the top, and swivels on a stud fastened in the slide, the worm being driven by the chain shown through a pair of universal joints. The power is taken from the feed rack driven by the friction.

Another very substantial method for planing either concave or convex surfaces is shown in Fig. 93A. This consists of a heavy master cam bolted to the housing faces and having the cam slots as shown each carrying a roller

which revolves on a stud. These studs are fastened into the nuts on the down feed screws. As these down feed screws do not extend into the regular nut in the

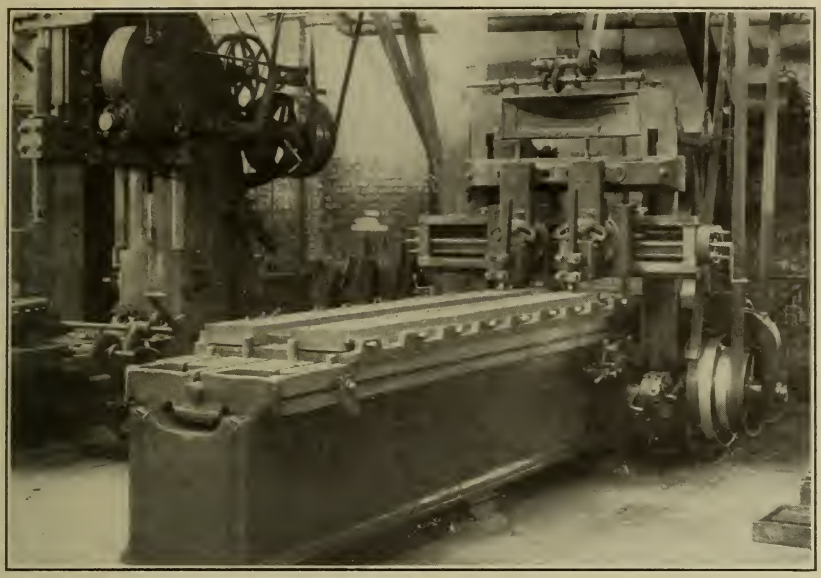


FIG. 93A.—36 in. standard planer with radius attachment.

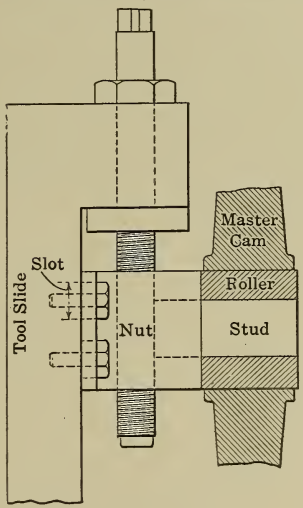


FIG. 93B.—Side view.

harp it will be seen that the slide is free to move in a vertical position and follow the curvature of the cam as the head is fed across. Yet the tool slides

have a vertical screw adjustment for setting the depth of cut, etc. By withdrawing the short screw and nut and replacing the regular down feed screw we have the standard construction. Details of this are shown in 93B.

Planing to a Templet

A good example of planing to a templet is shown in Fig. 94. This shows a large impeller lobe for a rotary pump. The templet cannot be seen as it is mounted on the impeller shaft at the other end of the work, so as to be at the

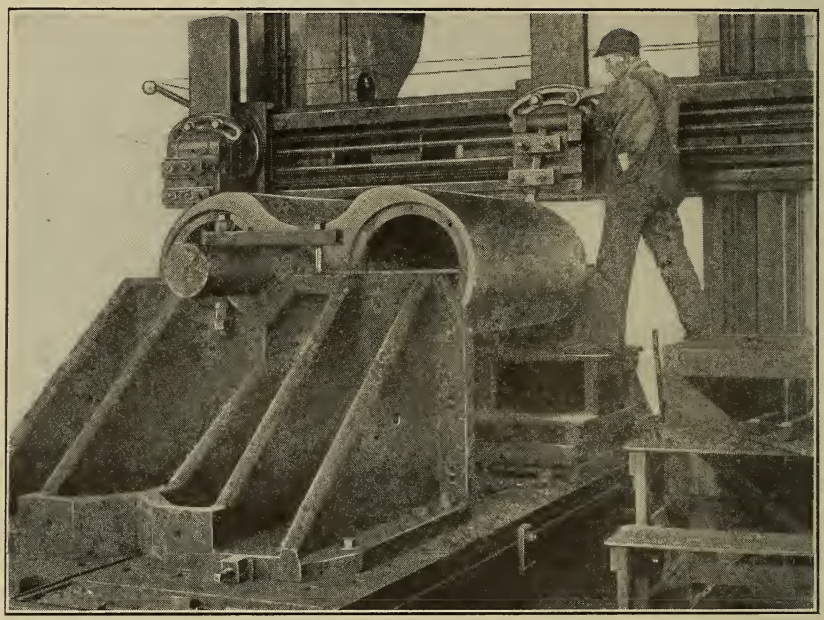


Fig. 94.—Planing impeller lobes to templet.

beginning of the stroke. It is of cast iron, about 1 1/2 inches thick. The view shows the workman just setting the finishing tool to the templet.

Fig. 95 shows the planing of a keyway in a heavy gear. The keyway is very long and the tool must reach through the hub. A tool head is at the end of the bar so that the cutting tool may be relieved on the return stroke.

Using Planer Centers

While the use of centers in planing is not common there are places where it is of considerable value. An instance of this is shown in Fig. 96 where a guide for a fire engine is being planed so that the square, guiding surfaces may be central with the turned ends. These ends fit into the engine frame

at both top and bottom and it is necessary to have the squares equally distributed around the center line of the guide.

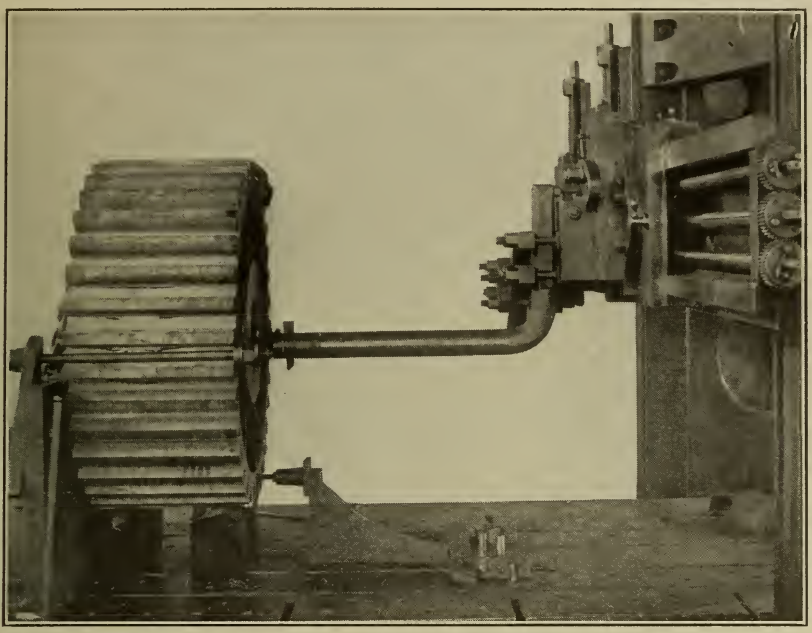


FIG. 95.—Planing keyway in a long hub.

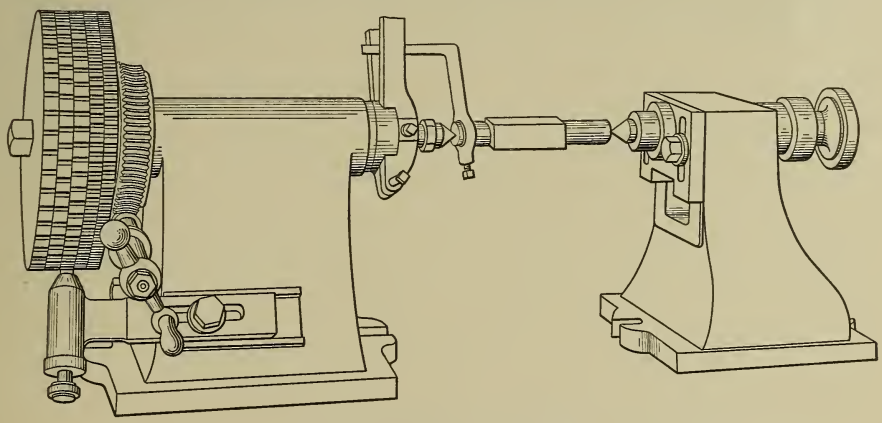


FIG. 96.—Using planer centers.

The work is held by some sort of a dog to the index center, and supported by the tail center. On long pieces a block or planer jack is placed under the

part being planed to prevent springing of the piece. After one side is planed, the work is indexed to the next position by turning the index head by means of the worm and until the work is in the correct position for the planing of the next side.

Cutting Oil Grooves in Gibs

The Bullard Machine Tool Company, Bridgeport, Conn., has a small planer rigged up, as shown in Fig. 97, for cutting the zigzag oil grooves in flat gibs.

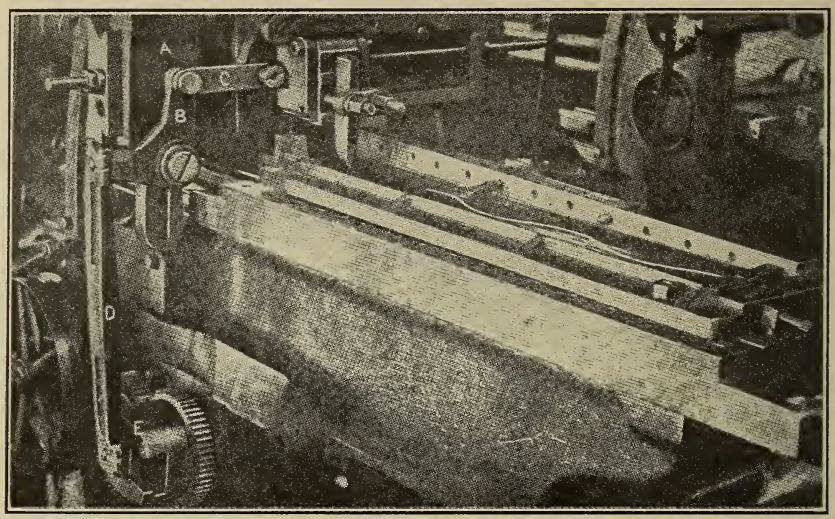


Fig. 97.—Cutting oil grooves in gibs.

The bracket *A* carrying the rocking arm *B*, is placed on the cross-slide ways and clamped in place by setscrews; the rocking arm *B* is coupled to the tool carriage by the link *C*, the carriage, of course, being disconnected so as to be free to move back and forth on the ways; the rocking arm is given its motion through the connecting rod *D* and the block crank *E*, the stroke being regulated by adjusting the block to which the end of the connecting rod is fastened.

The tool used is similar to an ordinary narrow round-nosed tool, except that it is relieved rather abruptly back of the cutting edge, and as the planer table is reversed the tool is lifted by hand and dropped into place at the beginning of the groove as the table runs back.

There are many jobs of irregular planing which can be done easily and cheaply by modifications of this method.

Marking Hard Castings

As planing is usually the first operation, some shops depend on the planer hand to act as a guide for the following operations, so far as the hardness of the metal is concerned. If he strikes a casting which is harder than usual, he marks the word "hard" with chalk in a conspicuous place where it will not be rubbed off, and this is a guide to all future operations. On seeing this the milling machine man will adjust the speed of the milling cutters accordingly so as not to dull them as would be the case if run at the usual speed, and as milling cutters represent quite a large investment, many dollars can be saved in this way during a year. It is simply an example of cooperation between departments which should be very much more common than it is, and everyone in the shop should feel that they are working for the best interests of the shop as a whole instead of trying to make a show for their department at the expense of the rest.

Planer Feeds

On light cuts the feed of the tool should take place after the tool has cleared the work on the return stroke and before it starts in on the next cut. On heavy cuts or coarse feeds the tool should feed during return stroke as this will cause tool to ride on the heel and saves the cutting edge. This wear is of

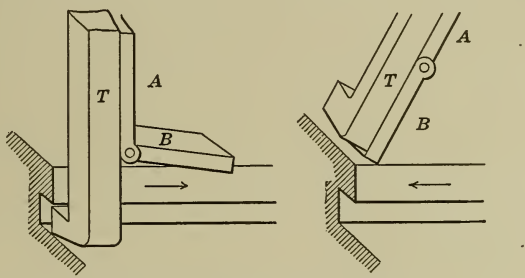


Fig. 98.—The tool lifter and how it works.

course also prevented by tool lifters, which are simple and can be used in nearly all cases. They are actually necessary in planing T-slots or undercuts of any kind unless the planer hand wants to be sure and lift the tool every time. The tool lifter is shown in outline in Fig. 98 and its use in actual work in Fig. 99.

The width of feed varies widely with the work being done, the average probably being from 1/8 to 1/4 inch. When planing to a finished edge as with dovetail work, a feed of 1/16 inch may be necessary to prevent breaking the edge where it is reached by the tool.

Generally speaking, however, the feed should be as wide as possible on

account of saving as many strokes as possible. If we can use a 1/4 inch feed instead of 1/8 inch, we have not only saved half the cutting time but half the time taken by the return as well.

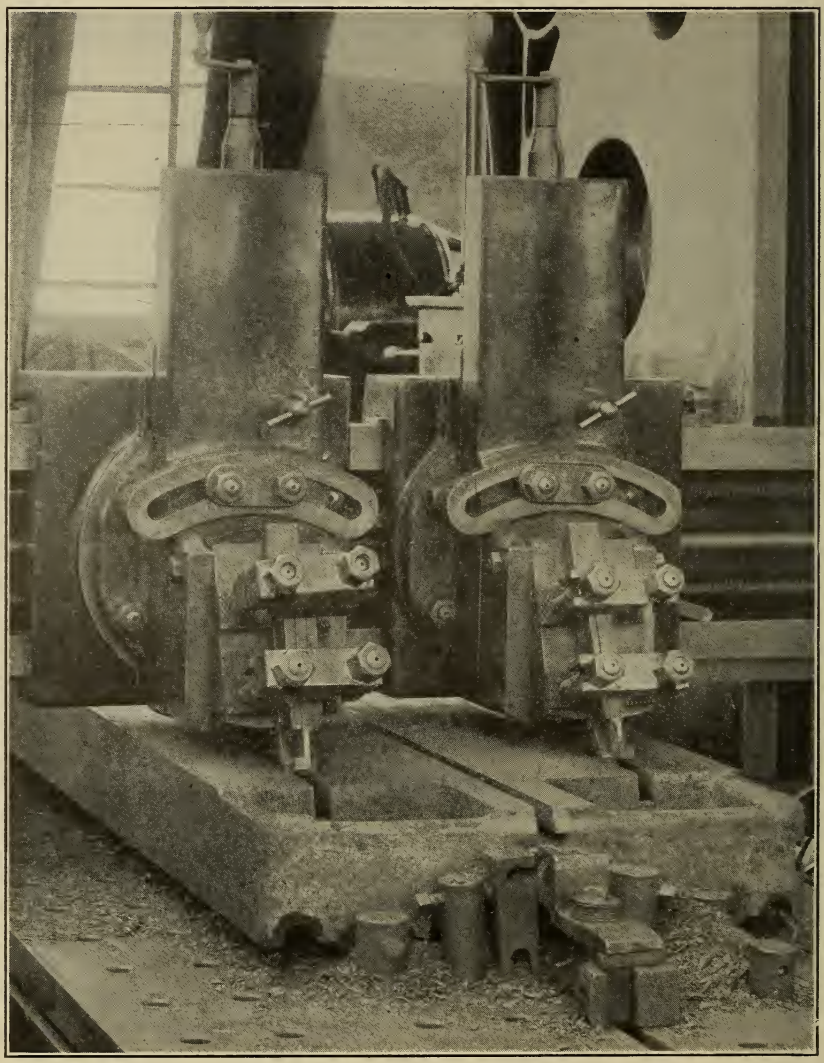


FIG. 99.—The tool lifter in use.

It should also be noted that a good planer hand considers what will happen when the tool breaks through the cut. In many cases he chips a good bevel

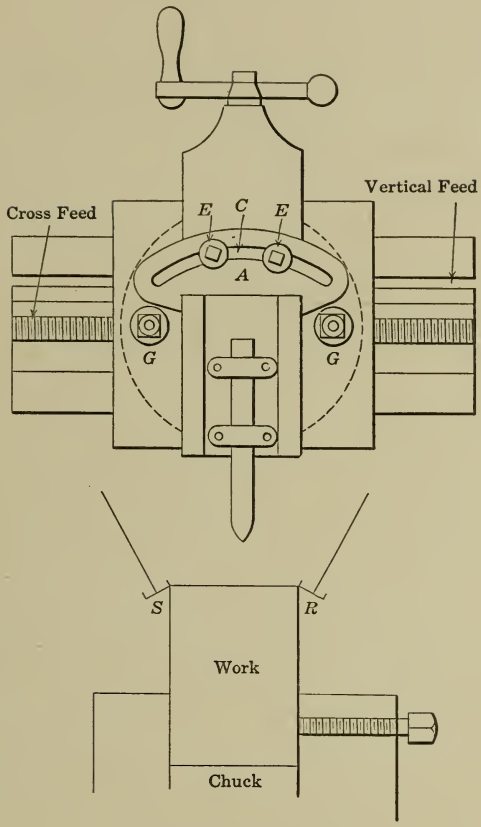


FIG. 100.—Using the apron.

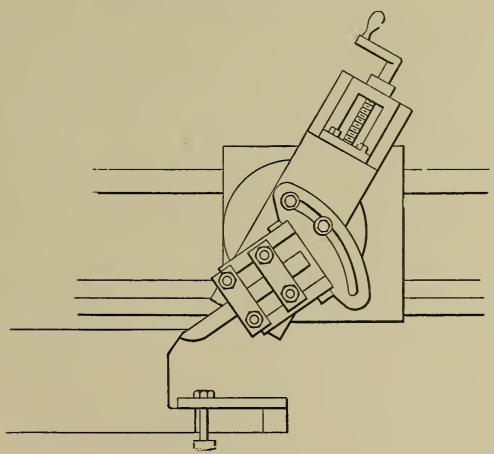


FIG. 101.—Using the apron.

on the edge where the tool leaves the cut to prevent leaving an uneven and unslightly edge. This can often be avoided by casting a bevel edge instead of a sharp corner.

Using the Apron

The uses of the swivel or apron on the planer slide is sometimes overlooked. It is especially useful when planing vertical or angular surfaces. In all work of this kind the swivel should be swung out of center with the tool slide so as to bring the cutting edge of the tool away from the work when the clapper block is lifted for the return stroke. Fig. 100 shows by the lines *L* and *R* how the swivel should be set off to plane down the sides of the work shown in the cut. This is shown a little more clearly in Fig. 101 where the tool slide is set off to plane the angle of the dovetail and the swivel is set off still more in order to lift the tool clear of the work and prevent dragging and dulling on the return stroke. This dragging would be increased by the fact that the tool springs slightly away from the work during the cut and springs back again for the return stroke.

Using Micrometer Dials

The micrometer graduations on feed screws have become very common on many machines and is equally useful on the planer. Fig. 102 shows the dials on all the feed screws and also the graduations on the swivel base. These are better understood than the dials in many places. They can be used for spacing slots, etc., crosswise, also for tool adjustments to take side cuts on work to get the exact width without making several attempts and calipering after each cut thus saving time and doing away with the chances of spoiling work by cutting too deep.

The use of the collars shows the exact movement given to the tool in any direction, more accurately than can be measured with a scale, and saves a large amount of time. A little practice in using these collars will be well worth while.

Cutting Speeds

The question of cutting speed is always important as well as the rate at which the work shall be brought back on the return stroke. More importance is sometimes placed on the quick return than is warranted by the results obtained, due to a failure to consider the real net increase in the reduction of the total time required.

High speed steel has greatly increased the speed of planing as in other cutting operations, 55 feet per minute being about as high as can be used to advantage in most cases. There are several reasons for this although all do not agree as to the various causes.

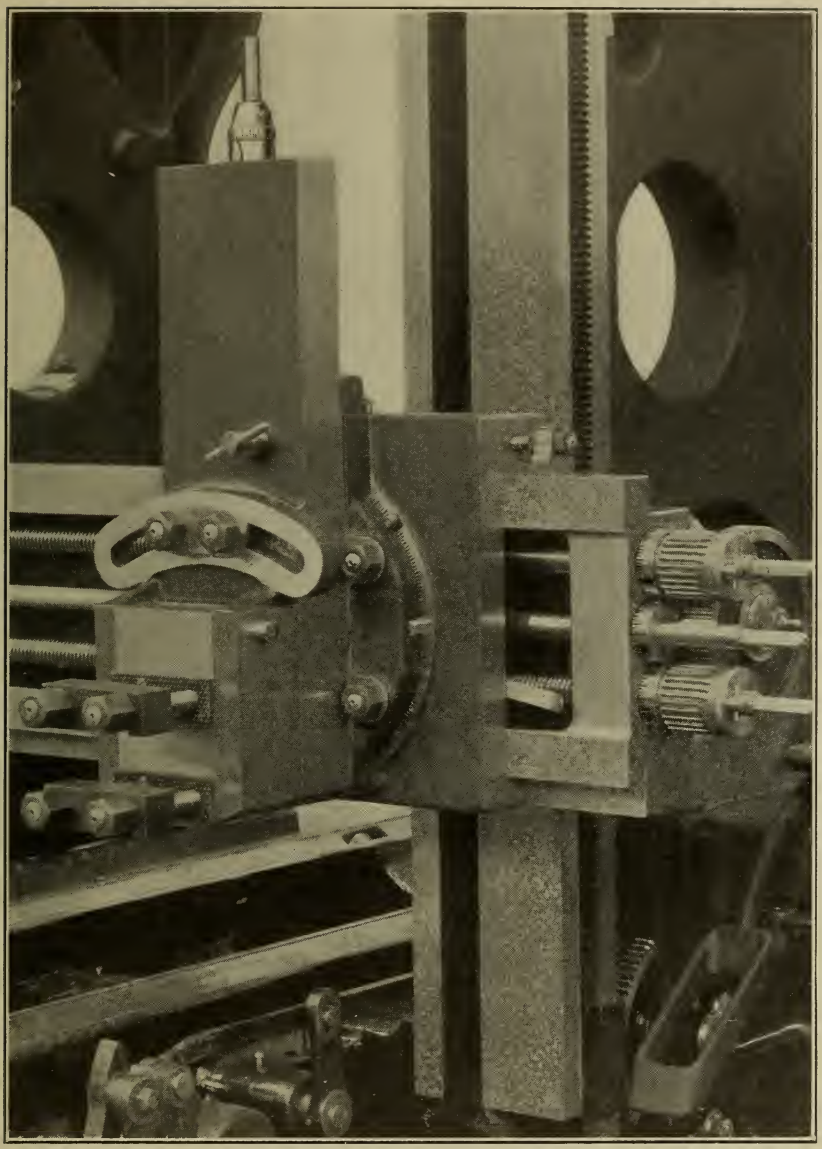


FIG. 102.—Graduated swivel and collars on feed screw and side screw.

On long, continuous cuts, the planer tools will not stand the speed of the lathe tool, probably due to the lack of cooling lubricant. In fact there are some shops where the tools stand up under a higher speed if the cut is not continuous. For example it is not uncommon to find that a string of lathe carriage tops or bridges will be planed at a higher speed than the lathe beds. The reason usually given is that the gap between the pieces allows the tool to cool somewhat between the carriages instead of keeping it at the higher temperature during the whole of the cut.

Practical Cutting Speeds

While the best speeds to be used in planer work vary greatly according to the conditions of the work, the following suggestions should prove of value as a guide, as they represent the practice of some of the best shops:

Cast iron, roughing,	40 to 50 feet per minute.
Cast iron, finishing,	20 to 25 feet per minute.
Steel castings, roughing,	30 to 35 feet per minute.
Wrought iron, roughing,	30 to 45 feet per minute.
Steel castings, finishing,	20 feet per minute.
Wrought iron, finishing,	20 feet per minute.
Bronze and brass,	50 to 60 feet per minute.
Machinery steel,	30 to 35 feet per minute.

Return Speeds

The return speed of planer tables has undergone quite a change in the past twenty years. It was early discovered that the return stroke of the table should be at a faster speed than the cutting stroke and the two to one return became quite common.

But some fifteen years ago there was an awakening all along the machine line and much higher return speeds came into vogue. This reached its extreme in a return of about seven to one and has now come back to about 75 to 100 feet per minute, which is a fair compromise and gives the best commercial results.

The sudden reversal of a heavy mass of metal requires power to stop the load and start it again. This action reverses the strains on the shafting, the gears and the keys which drive them. When this is done frequently it adds much to the power consumption of the tool and becomes quite a problem.

With a return at the same speed as the cutting stroke it is very clear that the actual or effective cutting speed is only one-half of this. If the forward cutting stroke is 20 feet per minute and the return is at the same rate, the effective speed is only 10 feet per minute. If we double the return speed we do not

increase the effective speed nearly as much as we might think. To see just what this is, let us look into the question a little.

If the planer is cutting 20 feet per minute with a 2 to 1 return, it takes 1 minute to run forward 20 feet and 1/2 minute to return, or 1 1/2 minutes for the round trip. To find the actual number of feet cut per minute we must allow for the return stroke. To do this, call 1 1/2 minutes 3/2, divide 20 by 3 and multiply by 2 and we have 13 1/3 feet per minute, the time for the other 6 2/3 feet being taken by the return stroke.

If the return is 3 to 1, the time for the round trip is 1 1/3 or 4/3 minutes. Dividing 20 by 4 gives 5 and 3 times 5 or 15, shows that this only gives an actual cutting speed of 15 feet per minute.

Even increasing the return up to 8 to 1 only gives 17 3/4 feet, or only a little over 4 feet gain over the 2 to 1 return.

But if we increase the forward speed to 25 feet per minute the effective speed is 16 2/3 feet per minute with a 2 to 1 return and with the usual 4 to 1 return, it gives an effective cutting speed of 20 feet per minute.

This shows that much more is gained by increasing the forward speed even a small amount than attempting to run a very high return speed. It is also very much better for the mechanism of the planer.

The following tables will be found convenient for comparing planer speeds.

NUMBER OF FEET TABLE TRAVELS PER HOUR ON CUT

Speed of cut	Speed of return per minute							
Feet	50	60	70	80	90	100	120	150
20	857.14	900.	933.33	960.	981.81	1000.	1028.57	1058.82
25	1000.	1058.82	1105.26	1142.86	1173.91	1200.	1241.38	1285.71
30	1125.	1200.	1260.	1309.09	1350.	1384.6	1440.	1500.
35	1235.29	1321.31	1400.	1460.87	1512.	1555.55	1625.80	1702.702
40	1333.33	1440.	1527.27	1600.	1661.54	1714.28	1800.	1894.74
45	1421.05	1542.85	1643.47	1728.	1800.	1862.06	1863.63	2076.92
50	1500.	1636.36	1750.	1846.15	1928.57	2000.	2117.64	2250.

Divide by length of stroke to get number of strokes per hour.

THE TIME OF PLANER TRAVEL PER FOOT

Travel feet per minute.	Time one foot.	Travel feet per minute.	Time one foot.
10	6. sec.	105	.571
15	4.	110	.545
20	3.	120	.5
25	2.4	130	.461
30	2.	140	.428
35	1.72	150	.4
40	1.5	160	.375
45	1.333	170	.353+
50	1.2	180	.333
55	1.09	190	.316
60	1.	200	.3
65	.923	220	.273
70	.857	240	.25
75	.8	260	.23
80	.75	280	.214
85	.705	300	.2
90	.666		
95	.631		
100	.6		

The first table shows the number of feet per hour the planer is cutting or is on the cutting stroke. Taking a 30-foot cutting stroke and a 60-foot return and we see that it gives 1200 actual cutting feet per hour. This also shows very plainly that it is better to increase the cutting speed 5 feet per minute, mak-

ing it 35 feet, and keep a return speed of 70 feet per minute, than to retain 30 feet cutting speed and jump the return up to 100 feet per minute.

The second table puts the same information in another way, by showing time in seconds taken to travel 1 foot, at the different speeds shown. This shows that if the cut is 40 feet per minute, the time per foot is 1.5 seconds. If the return is 80 feet per minute, the time per foot is .75 second. Adding these together gives 2.25 seconds as the time for a foot in both directions and by dividing 60 seconds by 2.25 we get the exact actual cutting speed per minute, or 26.66 feet per minute. Or we can guess very near this by noting that 2.25 seconds per foot comes between 25 and 30 feet per minute.

Light Pulleys

It seems a little strange to discover that the main source of power waste in reversal is not due to the load of the table and the work, but to the driving

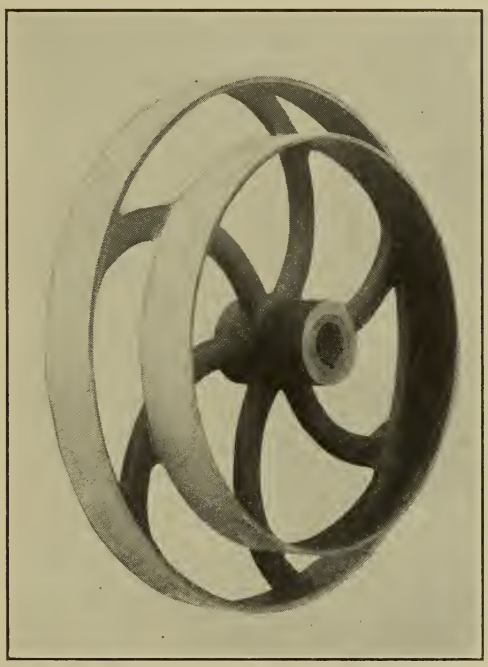


Fig. 103.—Alloy pulleys with cast iron bushing.

pulleys. For, while these do not weigh nearly as much as the reciprocating parts, these pulleys are traveling at a very high speed and storing up fly wheel inertia. Having discovered this, some of the leading planer builders are now

making their driving pulleys of aluminum which greatly reduces the inertia or the energy stored up in the pulleys, allowing them to be reversed much more easily and so consuming less power.

Aluminum alloy pulleys reduce the weight about 60 per cent., and greatly reduce the horse power required to drive the planer. For, instead of the power being required to reverse the heavy table and the work being done, the power is consumed in reversing the high speed pulleys and fast running parts. The most power is taken when reversing and not during either stroke.

Tests made by the Cincinnati Planer Company with 35 foot cut and 85 foot return with cast iron pulleys gave 165 strokes in 30 minutes, while with aluminum pulleys 189 strokes were made in the same time. The stroke was 4 feet in each case.

This saving in time is due to the quicker response of the light pulleys in reversing which also makes it possible to plane much closer to a shoulder should this be necessary.

In another test with a 72 inch motor driven planer, cast iron pulleys took 39 horse-power at the reverse while only 30 horse-power was required with the aluminum pulleys. These figures show a saving of nearly 25 per cent. in power and a gain of 15 per cent. in the number of strokes per hour.

Fig. 103 shows these alloy pulleys having a cast iron bushing so as to secure a good bearing.

Slide Rule for Timing Work on Variable Speed Planers

Figs. 104 and 105 illustrate applications of a new form of slide rule brought out by the Cincinnati Planer Company, Cincinnati, O., for determining the length of time required to machine work on planers under varying conditions as to cutting speed, return speed, and rate of feed. The rule is adapted for computations involving cutting speeds from 20 to 60 feet per minute, return speeds from 50 to 130 feet per minute, and feeds ranging from 1/16 to 1 inch per stroke.

The upper portion of the rule has in place of the usual "A" scale, a set of curves representing the different cutting speeds, and the points of intersection with the horizontal lines representing the different return speeds, determine the setting of the slide, scale B of which represents the various rates of feed from 1/16 to 1 inch. Scale C of the slide is graduated for surface areas up to 3000 square inches, and scale D gives in minutes or in hours the time required to plane any given area.

The area of the surface to be planed, that is, the length in inches times the breadth, in inches, is determined at the outset in the usual manner, either mentally or otherwise, as may be most convenient.

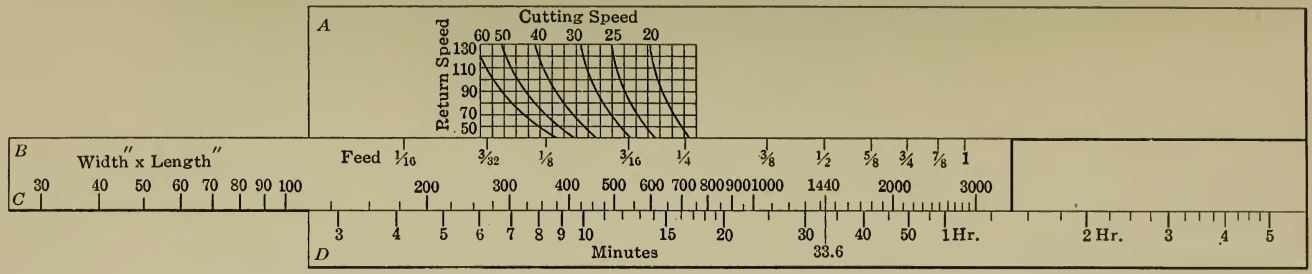


FIG. 104.—Slide rule set for cutting speed of 40 feet, return speed of 100 feet, feed of 1/8 inch.

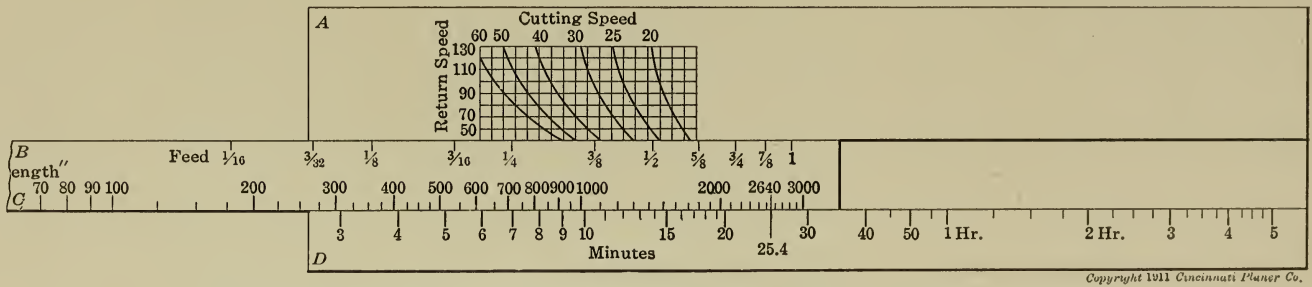


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FIG. 105.—Slide rule set for cutting speed of 30 feet, return speed of 90 feet, feed of 3/8 inch.

Assume, for example, that the work under consideration is 10 feet long by 12 inches wide, and a cutting speed of 40 feet, return speed of 100 feet and feed of 1/8 inch have been selected as suitable: Scale B is set as in Fig. 104, with 1/8 under the point of intersection of the 40-foot curve with the line representing a return rate of 100 feet, and opposite 1440 on scale C (length times breadth in inches), read 33.6 minutes.

Or, suppose the work to be 11 feet long by 20 inches wide and the surface to be gone over therefore 2640 square inches. Also assume a cutting speed of 30 feet per minute, a return speed of 90 feet and a tool feed of 3/8 inch have been selected. The slide rule is now set, as in Fig. 105, with the 3/8 line of the B scale directly under the intersecting point of the curve for 30 feet and the line for 90 feet return speed. Opposite 2640 on the C scale, will then be found on the D scale 25.4 minutes as the time necessary to complete the operation.

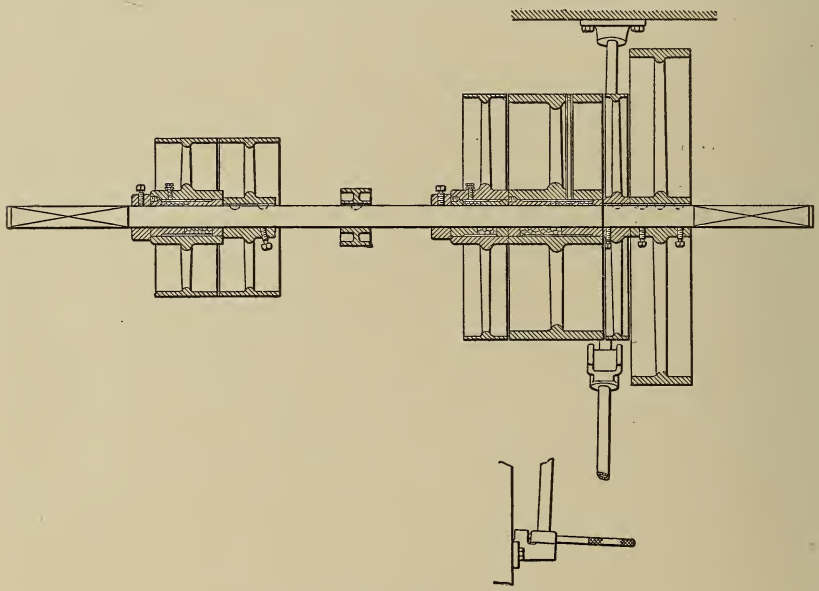

Fig. 106.—Two-speed countershaft.

In figuring the length of a piece, allowance should be made if the tool overruns the work at either end of piece. It will be found that this rule is very close to the actual figures if the reversing of the planer is prompt.

To meet the increasing demand for more than one speed on a planer, the Cincinnati Planer Co. have developed the two-speed drive shown in Fig. 106, giving two cutting speeds to the table and a constant return. Any two cutting speeds wanted can be provided with this drive, and the changing from one speed to the other is accomplished instantly while the machine is running.

The drive consists of two sets of pulleys, one keyed to the shaft and the other a wide faced pulley running loose on the shaft. Both are driven by independent belts from the line shaft and run at different speeds. In addition we have the usual extra heavy return pulley and the cutting pulley, both keyed to the shaft and adjoining the wide faced pulley. By operating the lever shown at the side of the housing we obtain the two speeds. The high speed by moving the belt to the right on to the cutting pulley and the low speed by moving the belt to the left on to the wide faced pulley. The return belt remains in one position giving us a constant return of table.

Variable Speed Electric Driven Planers

In addition to mechanical means for varying the cutting speeds of planers of the newer types, the electric driven planer is also making its way. These are

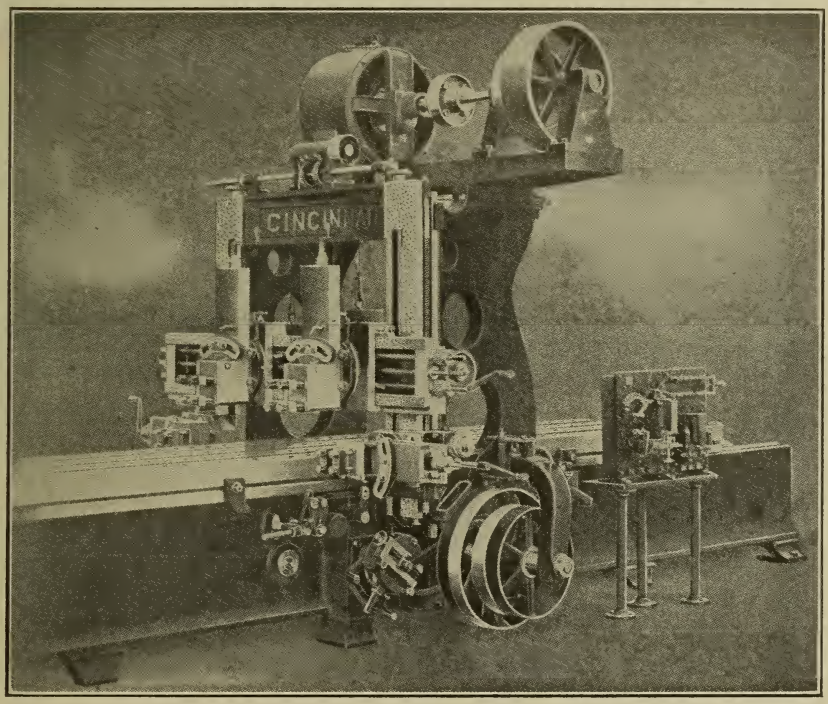

Fig. 107.—Cincinnati electric variable speed planer.

operated in several ways by controllers and starting boxes. They are so arranged that any cutting speed between 25 and 50 feet per minute can be obtained without in any way affecting the return speed. The return speed can also be

varied from about 60 to 100 feet per minute without affecting the cutting speed. This makes possible many combinations such as a 40 foot cutting speed and a 60 foot return speed or a 20 foot cut and a 90 foot return. The switches are so

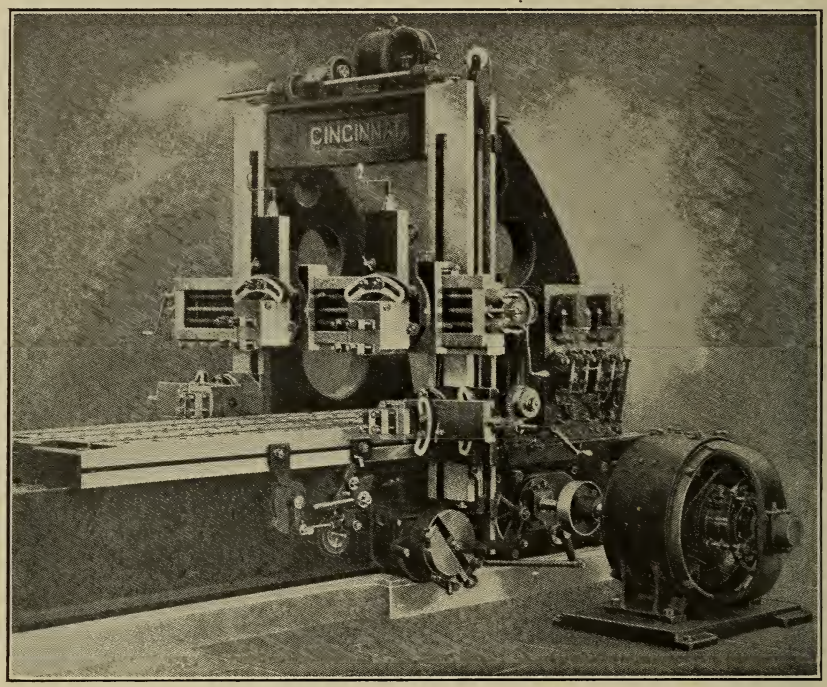

Fig. 108.—Cincinnati reversible motor driven planer.

set that the motor will automatically return to any particular speed for each stroke.

In Fig. 108 is shown a reversible motor-driven type of planer. This drive enables a motor to be used which is much smaller than is usually applied on top of the machine, simply because there are no large pulleys to gather flywheel inertia, and have to be stopped and reversed in the opposite direction. Consequently there is a reduction in the peak load at reversal, and the current consumption is correspondingly less. Furthermore, there is an absence of noise. There are no belts to maintain and replace, and the planer will operate on a short stroke of 5 or 8 inches for hours at a time, without heating or extra consumption of power. This drive is particularly adapted to large planers where the gear ratio is high and the pulleys have more flywheel inertia, and it permits a more constant short stroke than could be otherwise obtained where

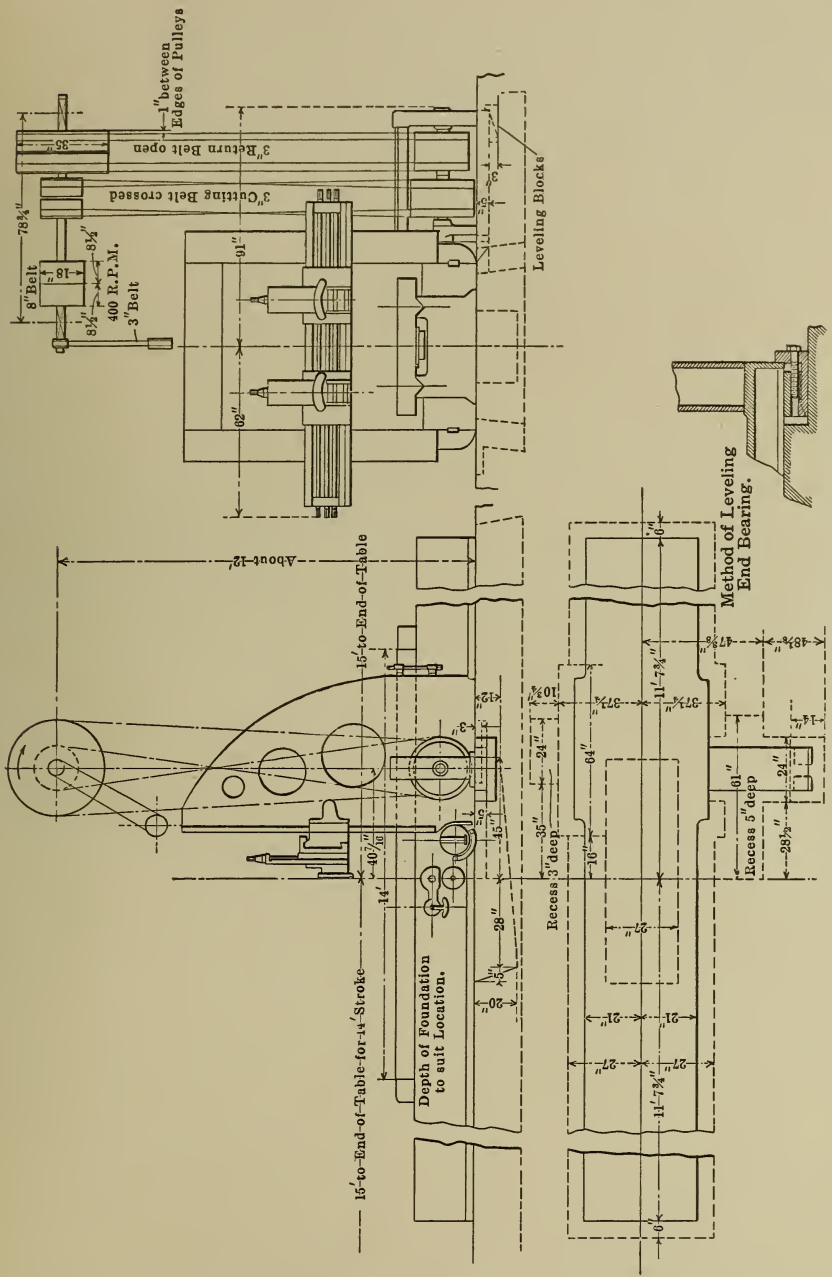

FIG. 109.—Foundation plan of 62x62x14-ft. planer.

there is stretching and slipping of belts and destruction of belts due to heating of the pulleys.

In place of the usual elevating device on top of the planer, there is a small motor attached with a double-throw switch, one side being used to elevate the rail and the other side for lowering the rail, thus doing away with every belt on the machine.

Foundations and Floor Plates

The foundation is a very important matter as no planer can do good work unless it is substantially supported. Most planer makers supply foundation plans with each planer showing the kind of foundation which they have found

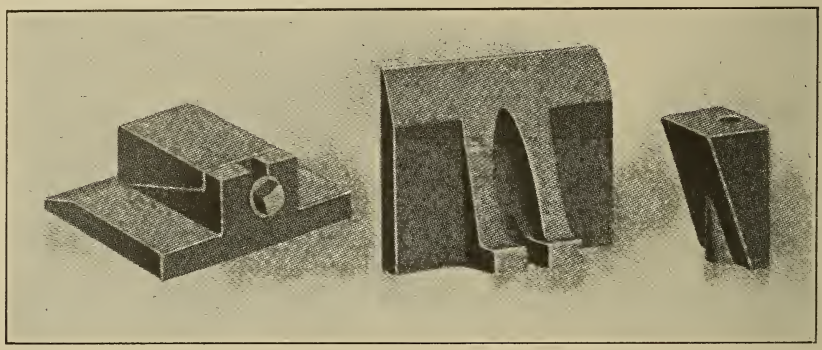

Fig. 110.—Improved leveling block.

best and the necessary depth for the planer to be installed. The foundation for a 62 × 62 × 14 foot planer is shown in Fig. 109. Concrete is used the most for this purpose.

Adjusting plates are being quite extensively used between the planer bed and the foundation. Where the planer has feet, they rest on the adjusting plates, but where the bed extends clear to the foundation, they are distributed at such points as seem best to carry the weight and support the bed without strain at any point.

Where adjusting blocks are not used, wedges having a slight taper should be so located as to support the bed perfectly and yet be out of the way of the feet, to avoid being jarred out of position and so affecting the alinement of the planer bed. Some prefer steel for wedges and others use cedar shingles.

The adjusting blocks shown in Fig. 110 are made by the Cincinnati Planer Company. They are very simple in construction and can be easily adjusted after they are in place.

With some such arrangement as this it is possible to correct quite an error

in the planer bed itself or in the foundation, and to bring it back to level in either case. No machine will show the effect of the settling of the foundation more than a planer, and we know of one instance where the giving way of a heavy floor support was only detected through its effect on the planer which was supported by it.

The adjusting plate shown in Fig. 111 is the one recommended by the Norton Grinding Company of Worcester, Mass., and used by them under all heavy machinery.

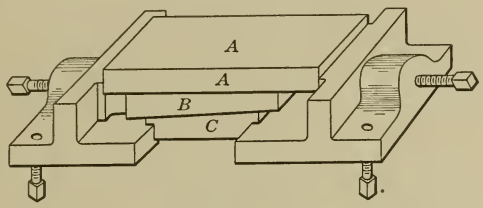

FIG. 111.—Another type of leveling block.

The concrete for the foundation is filled to within about 8 or 10 inches of the floor line and the adjusting plates located at the proper points. The four screws in each plate allow them to be adjusted very nicely and they are tested with a long straight-edge so as to hold tissue paper tight under all of them when the straight-edge is passed from one to the other.

After they are adjusted to the desired accuracy the concrete is filled in practically level with the top of the plates but with spaces left so as to get at the end adjusting screw easily when this becomes necessary. After the machine is in place, covers are made for the openings over the screws to keep out dirt and chips. These are readily removed when necessary and the plates raised or lowered a fraction of a thousandth, by moving the wedges with the screws on the ends.

These adjusting plates consist of a main casting underneath, which is made very heavy and which has a stiff truss beneath to prevent springing when the screws are tightened. The whole device is carefully made, the surfaces being all planed and the wedge guided by the customary spline and groove. The plate fits the entire surface of the wedge and it has been found best to put graphite between the surfaces in assembling, to insure a steady, instead of a jerky movement when adjustment becomes necessary. The ends of the plates are also planed to prevent lost motion.

As evidence of the efficiency of this foundation, Mr. Norton cites an instance of an 18×36-inch planer with an 18-foot bed which was tested after a year's steady use and found to be in perfect alinement. A 15-foot straight edge was used and would hold tissue paper at any three points on the table with the table in any position on the bed. This is a very severe test and few planers are so mounted

as to show these results, especially with the table in different positions on the bed.

A heavy concrete foundation of this kind with good leveling devices, make it possible to secure a higher degree of accuracy in planing than has sometimes been considered practical. They are somewhat expensive but planers properly supported do so much better work that much time is saved in scraping the work after planing and the time required to keep the planers themselves in first class condition is also much less than where adjusting plates and concrete foundations are not used.

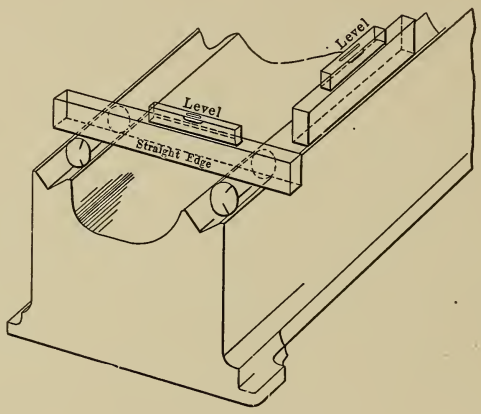

FIG. 112.—Leveling the bed.

Another interesting fact in connection with these foundations in the Norton shop is that they do not find it necessary to bolt down a planer in any case. They drill the plates and put in a half inch pin at each side of one or more pairs of legs, to prevent sliding endwise. But they have cases where the pins did not touch the feet when the planer was put in place and in which the planer has never moved enough to bring the feet against the pin.

There are grave differences of opinion on the question of bolting down planers at all as it is claimed that no planer which is heavy enough to do the work well will move at reversal and the belt pull can never lift them from their foundation.

LEVELING A PLANER

The main requirements of a planer are that the bed shall be true; that it be set level on the foundation and square with line shaft; that it bears evenly on the foundation or the plates or wedges; that it has sufficient bearing on it and that the cross rail be parallel or level with the table.

The planer ways should be level both *crosswise* and *lengthwise* excepting

where the bed only has legs at the end in which case it need only be leveled *crosswise*. This can be tested by removing table and using a good level, and then adjusting by the levelling blocks. The level should be long or be used on top of an accurate straightedge which is parallel on both sides and long enough to have a bearing across the bed as well as at widely separated points along the bed.

Where the top edge of the bed is planed accurately with the ways, as with the Cincinnati planers, this surface can be used in testing, but unless you are sure that this edge is true, the measurements should be made from the V's themselves. This can easily be done by taking two round bars or gauges of equal diameter and of a size suitable to use in the V's, as shown in Fig. 112. This allows the bed to be tested in both directions as can be plainly seen.

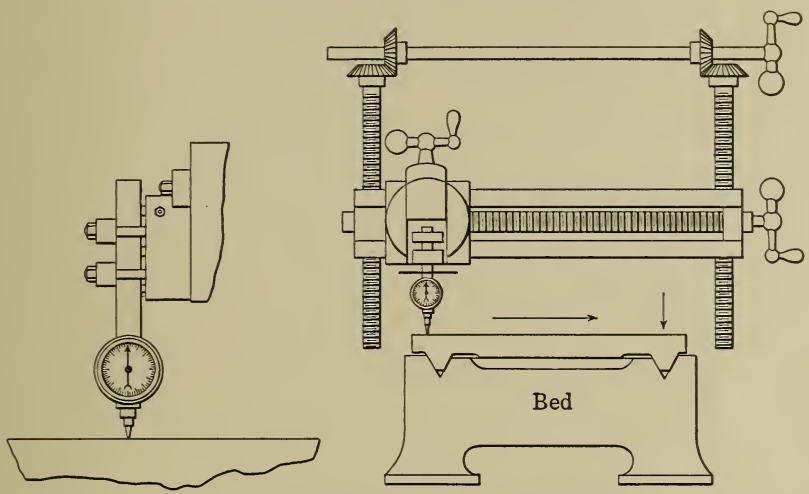

FIG. 113.—Testing the planer and cross rail.

Tests should be made at short distances apart both *lengthwise* and *crosswise* and it is customary to leave the bed a trifle high in the center, near the housings.

With a new planer tests should be made frequently to detect any settling or change in the foundation.

Special care should be taken with the lengthwise testing as all planers are not tested to a long straightedge but simply scraped to fit the table. This simply insures a bearing but does not show that they are level or straight.

TESTING THE CROSS RAIL

Having levelled the bed the next thing is to see that the cross rail is true and parallel with the table, which has been put back into place on the bed. This

can be done by measuring the distance between the cross rail and the table at the two sides of the table, using distance rods or a surface gage of some kind. If they are not the same, means of adjustment will be found on top of the bevel-gear in the uprights at each side in connection with the elevating screws. Always adjust by raising the low side, never by lowering the high side.

Fig. 113 shows a dial indicator clamped to a tool by means of which the variations, if any, are measured in exact parts of an inch. A distance rod may be clamped in the tool post and a piece of hard paper used as a feeler.

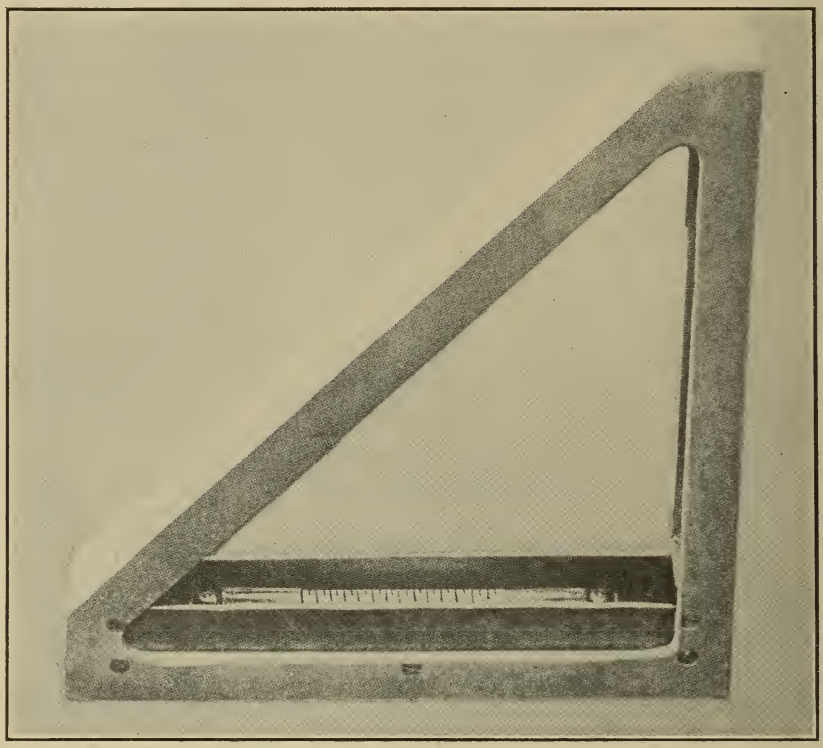

FIG. 114.—The special square used.

Use a piece of paper in any case and get the reading first on one side of the table and then on the other.

It was formerly considered necessary to plane off every table after the planer was set up, but modern practice is to plane each table on its own bed in the shop before it goes out, and it requires no planing if the bed is set as it should be on the foundation. In fact it is bad practice to plane the table in such a case as the trouble must be in the foundation and the wedges need adjusting.

Securing Accuracy in Building Planers

Although the user of the planer is interested in securing the best kind of work more than in the way the planer was built, a brief description of the way they are tested while being assembled in the Cincinnati shop will be interesting and instructive. This will be particularly useful where the planer has been damaged in shipment or where its accuracy has been impaired by an accident of any kind.

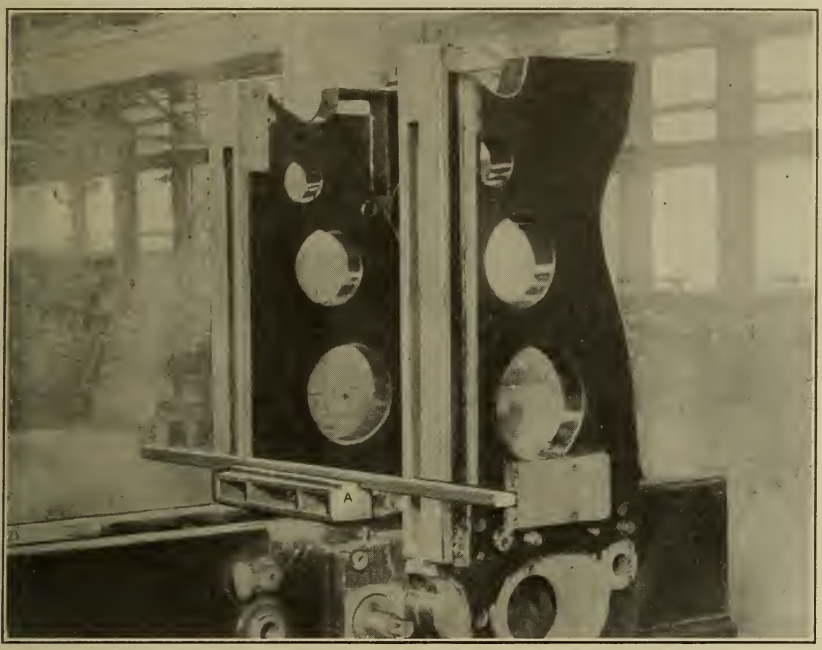

Fig. 115.—Using the testing fixture.

A special square, Fig. 114, is used for this work in order to secure extreme accuracy. This square has a special level accurately graduated so that each 1/8 inch graduation represents a variation of .001 inch in 4 feet.

The square is held against the housing and the position at which the bubble stops is noted. It is then placed against the opposite housing and the position again noted. Should they be different the graduations show how much they are out and in just what direction the correction must be made. When they have been adjusted so that the limit of error is one graduation or .001 inch of 4 feet, the holes in the housings are reamed and they are doweled into place on the bed.

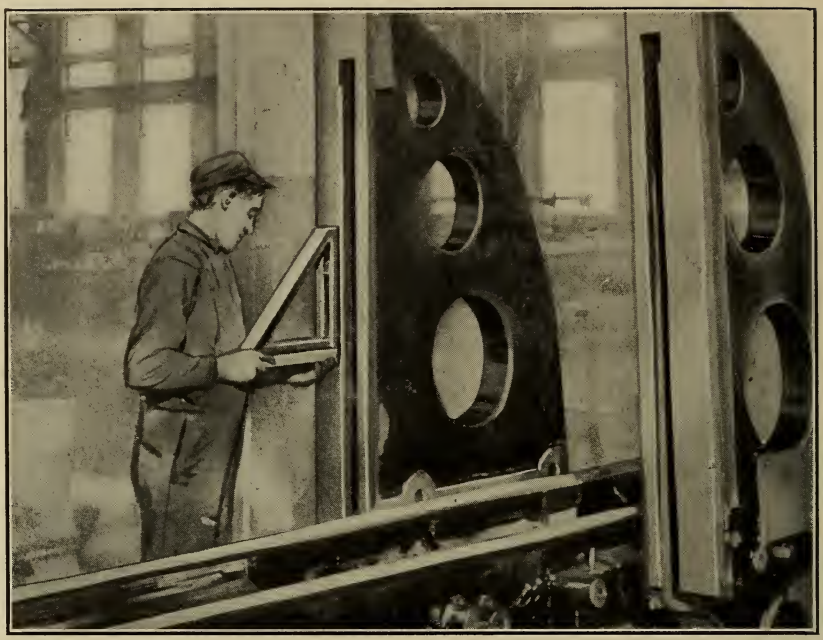

FIG. 116.—Testing the face of uprights.

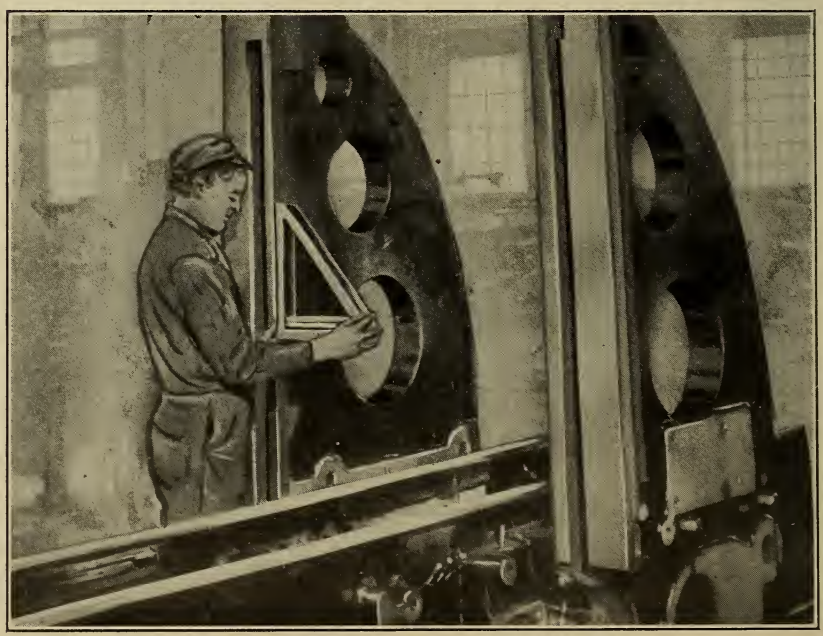

FIG. 117.—Testing the inside face.

After the bearings, shafts and gearing are put into the bed, the housings are put into place and tested before being permanently located on the bed. A fixture is placed across the bed as shown at A, Fig. 115. This fits into the V's and the edge shows when the housings are square with the V's.

A straight-edge is then placed on this fixture against the ledge on the fixture and the faces of the housings tested for square with the bed. After this is done the housings are tested for square on the side and face. This is shown in Figs. 116 and 117.

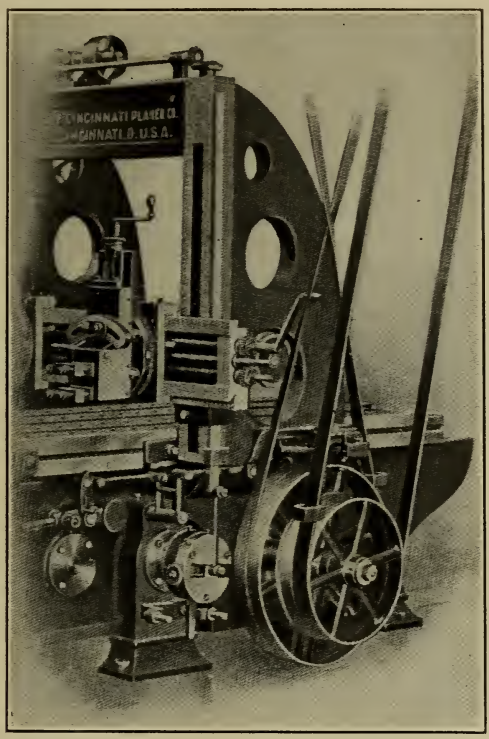

FIG. 118.—Showing how belt should be crossed.

STARTING UP THE PLANER

After the planer is set up and leveled, place the countershaft as shown in blue print which comes with it, level accurately and get it parallel with the line shaft. Give loose pulleys and hanger boxes a good supply of machine oil and see that pulleys and shaft turn freely. Adjust the collars on shaft to allow a little end play in boxes but not too much.

Use good double belting of width called for and put on as directed.

The cutting belt—the crossed belt in nearly all cases—should be crossed so that the side running back to the countershaft is on the inside toward the housing. The proper way is shown in Fig. 118 and is important. In this case the side of the belt operated on by the shifter forces the other side with it and the reversal is accomplished in less time than the other way.

After the belting is in place, turn the pulleys and gearing by hand to be sure that everything is free before using power.

The driving gears should have a good coat of heavy oil. The bearings and loose pulleys, as well as all oil holes, should have a good supply of the best machine oil two or three times a day for the first week. Large machines should be run idle a day or two before doing heavy work; this being more important than many realize.

Before the table is put in place be sure the V's of both bed and table are clean and free from dirt, that the oil pockets in the bed are well cleaned out and filled with good machine oil.

Don't take a cut off the top of a new planer table. It has been planed on its own bed and should be perfectly parallel with rail.

If rail is not parallel with top of table, it is due to shipment strains in most cases. Reset top ledge of rail parallel to top of table by adjusting small hexagon nut on top of elevating bevel gears.

Always raise the low side, never lower the high side.

Don't brush chips or dirt from table into the V's.

Don't clean out T slots in table without first running the table out so that no chips can fall into the V's or gears.

Don't let chips accumulate around the bull wheel.

Always use solid wrenches to keep corners on nuts sharp.

Protecting the Ways and Table

The ways of a planer must be true if good work is to be done and yet they are the most exposed of any bearing in any machine we use. On short work you often see a careful planer hand cover the end of the ways not being used, with narrow boards or with canvas. Some shops stretch a canvas or cotton-cloth canopy over the whole planer to keep dirt and chips from sifting down on the ways from the ceiling, from the cranes carrying castings with core sand in them or from the floor above when there is one.

A good method of planer-way protection is shown in Fig. 119. This is patented by W. A. Thelin, foreman of the planer department of the Bullard Machine Tool Company, Bridgeport, Conn., where is has been in use for a

number of years and has been very satisfactory in reducing the wear and damage and keeping the planers in better condition. As will be seen, it consists of two strips of heavy duck wound upon spools located at the end of the bed, the outer ends of the strips (which are of course somewhat wider than the V's) being attached to the end of the platen at points directly over the ways. The spools are mounted, as upon a spring-actuated shaft which, upon the platen moving forward, permits the protecting strips to be unwound; the tension of the springs, which are wound up by the forward movement of the platen, acting precisely like a window-shade roller spring to keep the strips taut at all times and rewind them on the spools as the platen returns.

To keep the canvas strips clear of the corners of the bed a pair of rollers

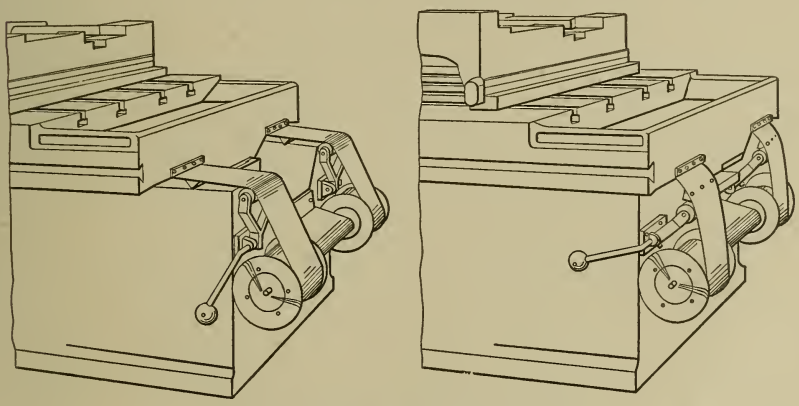

FIG. 119.—Planer way protecting device.

carried by swinging arms pivoted in suitable brackets are interposed between the bed and the spools. The pivoted members are weighted and normally the position of the rollers is that indicated at the left, the weights swinging the arms upward until a stop screw contacts with the end of the bed. In this position the rollers lift the strips above the ways and prevent their dragging on the edge of the bed during the travel of the platen. As the platen returns and the protecting strips are wound up tight on their spools by the action of the springs, the two blocks secured to the under side of the strips come in contact with the rollers carried by the pivoted arms and swing them into the position shown at the right, out of the reach of the V's under the platen. Upon the reversal of the machine and the forward movement of the platen the rollers again swing up into normal position to lift the strips clear of the edge of the bed.

They do not interfere in the least with long or short work and protect the ways at all times from cutting or scoring.

The table should be protected better than is done in many cases as it isn't a a good plan to use it for an anvil or a straightening plate, nor to let castings fall on it any more than necessary as it not only mars the table, but has a slight peening action that changes its shape more rapidly than might be expected.

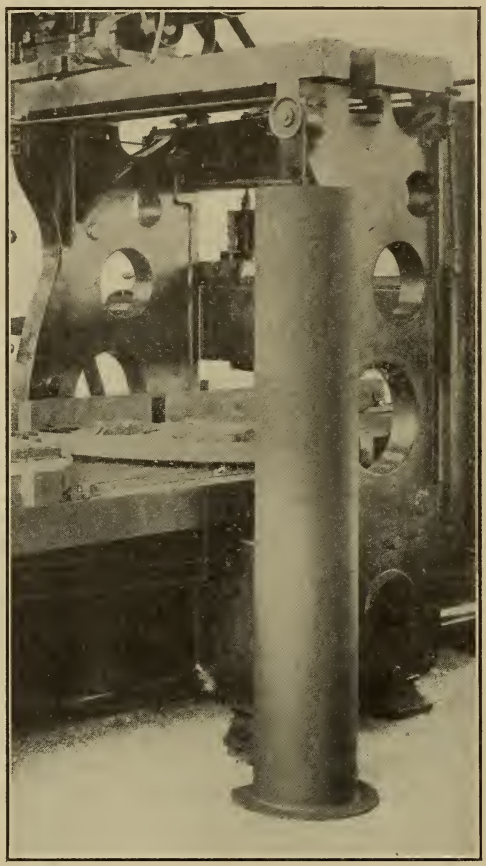

Fig. 120.—Guard for counterweight.

Some careful planer hands always lay boards or strips of old belting on the table when putting on heavy work in order to protect it from heavy blows should the work slip. These are then taken out by raising one side at a time and the work lowered onto the table itself.

A very neat and efficient guard to protect workers from injury by the falling of the counterweight on planers or similar machines, is shown in Fig. 120. It is

simply a light pipe of suitable diameter for the counterweight to go inside and having a flange for bolting to the floor. These are in use on all machines in the Cincinnati Planer Company's shop.

The Trigger or Feed Gear

As the satisfactory operation of the feed is very important in good planing the construction of the mechanism or trigger gear should be understood. This

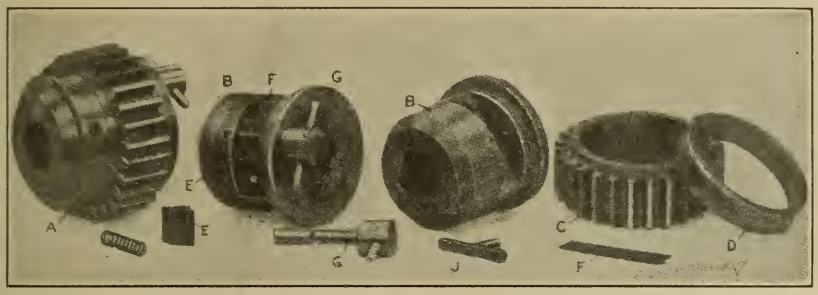

FIG. 121.—Planer feed gear assembled and taken apart.

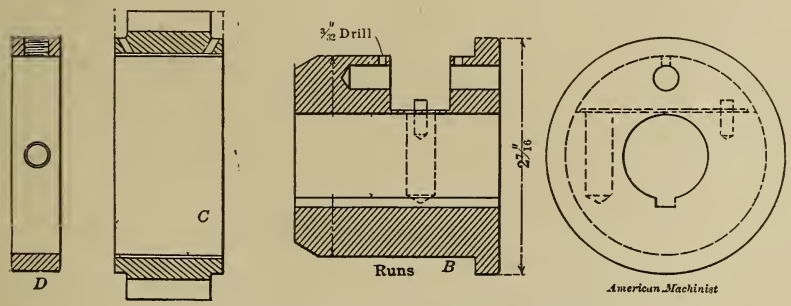

FIG. 122.—Details of planer feed or trigger gear.

feed gear unit is shown assembled at the left of Fig. 121 and at the right are the different parts, lettered to make the explanation easy to understand. Some of the details are also shown in Fig. 122.

The central body or hub *B* is bored and splined for a key to suit the end of the feed rod or feed screw and adapted to receive the operating gear *C* which is free to rotate between the flanges on the end of the body *B* and the retaining ring *D* which is secured by a screw near the end. The body *B* is milled cross-

wise to form a pocket to receive the pawl *E* which is normally held in neutral position by a flat spring plate *F*, seated at the bottom of this milled opening. The handle *G* can be turned to bring either of the working edges or the pawl into contact with the teeth inside the gear *C*. This connects the feed rod or screw with the movement of the feed gear train and transmits the feed in either direction as the handle *G* is turned into one or the other position.

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